

DOCUMENT RESUME

ED 311 868

IR 013 987

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TITLE Exemplary Classroom Computer Use. A Time for Tools.
Interactive Technology Laboratory Report #1.
INSTITUTION California Univ., San Diego, La Jolla. Center for
Human Information Processing.
PUB DATE Oct 83
NOTE 104p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC05 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; Computer Literacy;
Computer Networks; Computer Software; *Demonstration
Programs; Diffusion (Communication); *Educational
Planning; Elementary Secondary Education;
*Microcomputers; *Policy; Programing; Staff
Development
IDENTIFIERS California (Imperial Country); *California (San Diego
County)

ABSTRACT

The Policy Board of the Teacher Education and Computer Center (TEC Center) for San Diego/Imperial Counties of California requested researchers at the University of California, San Diego (UCSD), to produce a background paper on the effective local classroom uses of microcomputers. Exemplary site studies of two elementary, two junior high, and two high schools in San Diego County were conducted to examine several examples of innovative computer use and gain an understanding of future possibilities. One elementary school and two middle schools stressed programming as the central feature in the computer curriculum. The other elementary school and two high schools introduced students to a range of special purpose tools such as word processing, database management, telecommunications, and graphics, with programming playing a secondary role. Almost no drill and practice was observed at any of the sites. This result contrasts with reports of national and local surveys which reported drill and practice as the most frequent use followed by programming, and tool use being almost non-existent. The policy implications of this research are that the TEC Center should shift its emphasis from programming to software tool use, and should play a role in: (1) evaluating and distributing software tools; (2) coordinating an effort to open exemplary computer classrooms to visitors; (3) establishing telecommunications links between schools, curriculum developers, and institutions of higher education; and (4) supporting in-service training for teachers and administrators. Four appendixes include a summary of each exemplary computer-use site and three papers written by UCSD researchers which bear on this project. (27 references) (GL)

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Interactive Technology Laboratory

Report #1

Exemplary Classroom Computer Use A Time For Tools

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University of California, San Diego
October, 1983

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The preparation of this report was supported by the Policy Board for the Teacher Education and Computer Center, San Diego/Imperial County Region. The authors wish to express their sincere appreciation to the students, teachers and administrators at each of the six school sites for sharing their experience and knowledge with us and to the UCSD students who assisted with site observations and interviews.

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Exemplary Classroom Computer Use in San Diego:

A Time For Tools

EXECUTIVE SUMMARY

The Policy Board of the Teacher Education and Computer Center (TECC) for San Diego/Imperial Counties of California requested researchers at the University of California, San Diego to produce a background paper on the effective local classroom uses of micro-computers. Based on the results of this and other related studies, the following report makes recommendations for the consideration of the TECC Policy Board in its effort to establish programmatic and fiscal policy to guide the future activities of the TEC Center and its personnel. The report has three components:

1. An Executive Summary of the Report with a Statement of Policy Implications
2. The Exemplary Computer-Use in Education Study, and
3. Appendices including a summary of each exemplary computer-use site and three papers written by UCSD researchers which bear on the present project:
 - I. Summaries of Exemplary Computer Use Sites
 - II. Computers in Schools:
Stratifier or Equalizer (CUSG)
 - III. Education and Ecstasy: Computer Chronicles of
Students Writing Together (Riel)
 - IV. Computers in the Classroom: The Development
of Computer Use

Current Uses of Computers In Schools

In April of 1983, the number of microcomputers in use in San Diego and

Imperial County schools was approaching 1800 (Miller, 1983). Overall the number of microcomputers has increased by 160% over the two year period from 1980-81 through 1982-83. In the Fall of 1983, Apple Computer Corporation will donate one computer to each school in the State of California, adding at least 500 Apple IIe systems to those currently in use in the TECC service area. Several other computer manufacturers (Radio Shack, KayPro) are also planning somewhat less ambitious donations. We continue to receive reports of significant district purchases of microcomputers for classroom use even in these times of fiscal constraint.

Several studies have attempted to document the range of computer uses in elementary and secondary classrooms. A national survey (CSOS, 1982) on classroom computer use revealed a rather consistent pattern at both the elementary and secondary levels. On the average, the majority of user time was committed to writing programs. Drill and remedial CAI lessons was the next most prevalent. However, without considering per-user contact time, more sites reported CAI as the primary use of computers than any other application. In the same survey, teachers reported a decline in CAI use as they gained experience. Almost no instructional time was reported for using the computer as a tool for composing and editing text, graphics or music or as an aid in communication.

UCSD students led by Hugh Mehan (Computer Use Study Group) carried out a survey of computer use in 23 schools in San Diego county (CUSG, 1983; Appendix II). This study concluded that students' socioeconomic background was a good predictor of the type of computer use a student was likely to encounter. "Chapter one" students (mostly low SES) used computers for mathematics and language memory drills and "mentally gifted minors" (mostly

from middle class backgrounds) engaged in programming. Few of the students in the average ability range had access to computers on a regular basis.

The most prevalent instructional application of computer use was for basic skill instruction and computer literacy. When computers were used for basic skills instruction, students were given drill and practice materials which were coordinated with instruction they received in their classrooms. When students were exposed to computer literacy, they were taught how to program computers, mostly in BASIC. Computers were used for writing, music, and art, far less often than they were used for CAI and programming.

Like Tucker (1983), we are surprised at this order of priority. First, the full power and range of microcomputers are not being exploited when microcomputers are used for basic skills instruction and programming. There is little evidence to suggest that microcomputers can deliver basic skill instruction better than conventional techniques; and their utility diminishes when their high cost is taken into consideration. Second, the use of computers for basic skill instruction and programming does not match the needs of the world of work where microcomputers are used for text editing, spread-sheet analysis, and data-base management.

It is clear from the Johns Hopkins, UCSD and San Diego County studies, that the use of microcomputers in classrooms is significant and is likely to grow at an increasing rate over the next decade. But what will be the nature of future classroom uses and what will teachers and administrators need to know in order to more fully exploit the capabilities of this new interactive communication medium.

Will computers last in schools? Or, like other highly promoted educational innovations such as educational television or "new math," will they have a short lived existence? In evaluating the life expectancy of computers in schools, it is important to keep in mind that the impetus for their acquisition comes from sources which are external to the school. Computer manufacturers, computer-using businesses, and parents, fearful that their children will not develop skills needed in a technologically dominated marketplace, pressure schools to teach students about computers. These pressures highlight the relationship between schooling and the world of work.

The reaction of schools to this relationship may very well determine whether computers stay in schools. If schools adapt their curriculum to meet, indeed even anticipate the uses of computers in the world of work, then we can expect computers to be a viable part of schooling. Their viability will be increased to the extent that their impact on all aspects of the social system of the school is anticipated (Sarason, 1982).

If, however, schools continue to use computers as the majority of them are--as fancy teaching machines for basic skill instruction through drill and practice--then we can expect computers to recede in importance in schools. People will learn the more compelling use of computers, e.g., text processing, telecommunications, spread sheet analysis, data management, music and art, from sources outside the schools. If people turn away from schools to learn about information technology, then this social movement will have a profound impact on the structure and function of school as we know it (Illich, 1970).

While these reports provide normative descriptions of how computers are

currently being used in classrooms, they do not predict future trends. We choose to look at several examples of innovative computer use in San Diego area schools to gain an understanding of future possibilities. We made the assumption that much of what goes on in these classrooms will become a model for other educators as computers become more widely available and teachers gain confidence using them.

Exemplary Site Study

Of the 14 sites recommended by the TECC Resource Teachers, we selected two elementary schools (Eucalyptus and Ebony), two middle/junior high schools (Maple and Mahogany) and two high schools (Hickory and Hemlock), distributed throughout San Diego County (each school has been given a mock name). Our purpose was to describe the computer related activities at each site and identify features that made it stand out from other classrooms where computers are being used. It should be pointed out that no systematic attempt was made to identify all exemplary computer use sites prior to our final selection. Constraints of time and resources limited our choice to those recommended by TECC personnel.

Results. One elementary and the two middle schools stressed programming as the central feature in the computer curriculum. The other elementary and two high schools programs introduced students to a range of special purpose tools such as word processing, data base management, telecommunications and graphics. Programming seemed to play a secondary role in the curriculum at these sites.

Almost no drill and practice activity was observed at any of the sites.

This result contrasts sharply with the reports of national (CSOS, 1982) and local surveys (CUSG, 1983). These surveys reported drill and practice as the most frequent use followed by programming, while tool-use was almost non-existent.

We suspect part of the reason for the lack of tool use is that appropriate computer supported tools used to be scarce and expensive. Several "user friendly" tools such as word processors (The Bank Street Writer and The Writer's Assistant), graphics and animation systems (Gibson Light Pen and several Penguin Software products), sensible data base, communication and music systems and special purpose tools like Bill Budge's "Pin Ball Construction Kit" and TLC's "Rocky's Boots," are now being marketed. Such special purpose tools allow access to the power of computers even for novice users, which only a short time ago was available only to institutions.

Our analysis leads to several, short range conclusions:

1. There are many possible models for exemplary computer use.
2. Various acceptable achievements accompany diverse implementations.
3. There is a trend towards greater reliance on software "tools" in computer literacy instruction at all grade levels.

There is widespread readiness on the part of school boards and administrators to support computer use in schools. Many teachers also appear to be willing to devote the time necessary to develop the required computing and classroom management skills for implementation. The community and

business seem ready to assist.

The argument has been raised that these early developmental efforts at computer use in schools will eventually be replaced by a rather narrow "accepted notion" of the appropriate education use of computers. Reference is made to schools already falling into a rigid pattern of use in which LOGO and drill programs will reign in elementary classrooms, BASIC in the middle schools and Pascal at the high school level. Our prognosis is less grim.

It is true that in elementary schools, there has been a keen interest in LOGO both as an environment for learning planning, debugging and other problem solving skills, and as a specific tool for artistic design. But elementary schools are also using other software tools which provide opportunities for problem solving experiences: word processing, communication networking, animation, simulations and special domain environments. Moreover, teachers alert to promising new software are enriching their instructional programs and creating innovative classroom applications. Several teachers are currently using an "interactive text interpreter," designed at UCSD, to develop activities in creative writing. Others are exploiting the electronic networking capability of computers to enable real and non-real time communication among students (Riel, 1983; Appendix III).

One of the exemplary classrooms observed is a very interesting case in point. The teacher became interested in computers after parents donated two to the school. The teacher and the principal then got funding for more sophisticated machines and the teacher implemented a program of instruction based on LOGO, long before it was generally available. Now that LOGO is gaining widespread use, this teacher is now looking for new software to

enhance his program. While acknowledging the continuing value of LOGO to his curriculum, he is aware of the potential educational enrichment that may result if new developments like the Gibson Light Pen graphics system are integrated into the instructional program. Innovative "grassroots" teachers like these are a valuable asset to the education system in its effort to keep up with fast changing technology without losing its commitment to a sound education.

At the high school level, we need to reconsider the advisability of maintaining a limited Pascal or Fortran programming curriculum. The evolution in programming languages over the last three decades parallels that of the rapid development in hardware. Hundreds of languages were designed for general and special purposes. The continuous improvement of programming languages, the non-triviality of the changes and the lack of transitivity from one language to another, works as a filter for a number of students, limiting success to a relatively small segment of the student population. It is our view that programming, in its traditional sense, will not be a required computing literacy skill for the vast majority of computer-users.

Advances in programming has been both the cause and the result of the creation of special purpose software tools. With software tools, non-sophisticated users are able to manipulate a programming environment to achieve specific goals within the special purpose domain. A novice can rapidly learn to use an electronic spreadsheet to define a personalized budget "program." Within the environment created by the spreadsheet program, the user defines formulas, labels and formats that represents a specific budget, forecast, bank-account or payroll organizer. This way, users are actually tailoring a program for their specific needs without knowing all the

programming details.

Special purpose software tools exist to facilitate project-planning, industrial design, management, etc. Though these examples are oriented towards business-type activities, there are also school-oriented programs available to support simulated logic structures in game like environments, verbal and graphic story makers, music and animation composing tools, spelling checkers and other writing aids.

Learning to use a software tool is relatively easy compared to general-purpose programming languages. Most tools are menu driven providing a list of features available. Some have a tutorial or other online user help features. Options for corrections, escape and crosschecking of user intentions are usually provided. There is increasing demand for "user-friendly" systems. It is, in fact, this increasing expectation for more user-friendly systems that make general purpose languages (Basic, Pascal, Fortran) unattractive for most users. As demands increase, tools are being invented to aide even the professional programmers in their efforts to develop ever more sophisticated and user-efficient systems.

Alternative Entry Points

We feel that what makes these sites exemplary is the attempt on the part of these innovative teachers to identify alternative entry points to computer literacy. By encouraging their students to work with a range of computer supported tools in order to carry out useful tasks in school, everyone in the class has an opportunity to succeed in some context. Though programming does not have to be restricted to high achievers (at two of our

sites, everyone in each class serviced learned some BASIC and/or Logo programming) programming has all too often been used as a "filter" to restrict access to computers.

As machines become more powerful and less expensive, learning to program using a general purpose language will diminish in importance for the vast majority of the population. Currently, an individual is not required to learn to program to be an effective computer user. Certain skills will continue to be important such as editing and debugging, but these skills will be applied to the use of special purpose tools.

Consequences of Diversity

One interesting observation in the current study was the diversity of computer applications we encountered at the six exemplary sites. We observed almost no drill and practice activities in these classrooms. Three sites (one elementary and two middle-schools) stressed the development of Logo and/or BASIC programming skills. The other sites offered a curriculum which enabled students to carry out tasks and solve problems using a range of computer supported special-purpose tools. The most common activities were word processing, data base management, spread sheet analysis and graphics design. One elementary site had established a telecommunications link with a class on physically handicapped students at another school.

We suspect that this emphasis on computer supported tools and programming was one of the primary motivations on the part of the TECC resource teachers when they suggested these sites for our consideration.

There is evidence that as a teacher gains a sense of competence in using a computer, the range of applications increases. Over a period of one year, Black (1983, Appendix IV) followed the progress of three elementary teachers as they attempted to implement computers as part of their instructional program. Though the organization of instruction varied across sites, all three teachers gradually improved in their ability to integrate computer supported activities into their standard curriculum (as opposed to using the computer as an isolated center) and expanded both the quantity and complexity of computer supported resources available to their students. All found opportunities to utilize the computer in their own work as teachers, most notably word processing. None of these teachers claimed to be programmers (and still don't), yet each has gained a professional reputation for their ability to effectively use computers in their classroom.

A study is currently underway which addresses this issue directly. With support from the State of California and the National Institute of Education, Mehan, et al of UCSD are conducting a study of the impact of the introduction of microcomputers into elementary school classrooms. In this collaborative study, teachers from four North San Diego County classrooms are introducing microcomputers into the routine of the school day to facilitate instruction of mathematics, reading and writing. The goal of the study is to determine the influence of microcomputers on students' learning. The researchers are also interested in describing the effects that the microcomputer may have on classroom organization, student motivation and social relationships. When the study is completed in the Spring of 1984, Mehan and his colleagues want to be able to comment on the educational utility of microcomputers considered as "tools to enhance learning" rather than as microcomputers used as teaching machines.

Tools For Students

In the exemplary classrooms, there seems to be a change in emphasis from computer supported drills and programming as the primary focus to the use of tools. Computer Aided Instruction (CAI) generally refers to computer supported drills, structured dialogue and simulations carefully coordinated with objectives associated with the standard curriculum. Such configurations are often utilized in remedial situations and require considerable user "connect-time" to be effective. Computer Managed Instruction (CMI) has traditionally included computer supported tools designed to aid teachers in their work as teachers. Examples include student grade management and reporting, attendance, testing services and general word processing.

Computer use can be classified according to the amount of "user initiative" that is possible. CAI generally allows little user initiative while programming requires extensive problem solving and organizational skills on the part of the user. Computer supported tools fall somewhere in between. Such tools often allow novices to expand the range of tasks they can successfully engage in by providing support for skills not yet fully developed. For example, a non-artist can create a pleasing graphic illustration with the support of a quality graphics system. Existing "chunks" of a design might be selected from a menu and positioned to form a complete picture even though the user may not have the dexterity to draw the individual piece. Music, text and animation designers/editors allow similar support for various components of composing, writing or illustration tasks.

We conclude that effective computer use must now include tools designed

to aid students in their work as students. Though easy to use, each tool offers considerable insight into the capabilities of computers and can assist the user in a wide range of learning tasks. The following table lists common uses for computers in education according to the amount of user-initiative required to function effectively. Many of the "tools" can be effectively used by both teachers and students.

Categories of Classroom Computer Use

Low User-Initiative		High User-Initiative	
Comp. Assisted Inst. (CAI)		Computer Supported Tools For Teachers For Students	
Drill & Practice Content related memory tasks		Class lists Grade book Report cards Testing Word processing Planning Scheduling	Rockies Boots Pin Ball Construction Kit Graphics/Music/ Text Editors Data Base Spread Sheet
			Logo BASIC Pascal

Trends in Software Design

We discussed current product development with educational software designers and publishers around the country. Because of the normal development and field testing requirements for introducing new software products, these discussions of current programming efforts allowed us to make reasonable predictions about the likely features of software over the next two or three years. For this report, we focused on software for popular microcomputers.

Judged on number of programs being produced, we will see much more of the same: a large number of drill and practice programs, some packaged together by major educational publishers into massive curriculum packages.

However, if measured instead by the impact they will have on school use, we expect to see a significant number of quite different kinds of educational software: powerful educational games and software tools.

Educational Games. A significant number of educational games are being developed, driven by the demands of the home market. These will be "stand-alone" activities, designed for use by children with minimal adult guidance. Because of the home market target, these games will have to be entertaining enough to compete with computer games that don't attempt to be "educational." Most of these will be "extrinsic" games: traditional drill & test activities dressed up as a game. But there will be some new "intrinsic" educational games: those in which the skill to be learned is an integral part of the game environment. However, even these more interesting educational games will be difficult to use in instructional settings, because of the strong goals and randomization that are built in (two features which make a game engaging). Such games may be difficult to use in a school setting since instructional objectives are generally subordinate to the primary goal of winning (or successfully completing the task) and random presentation of situations may provide inconsistent practice.

Educational Tools. The most important development may well be the powerful new educational tools that will be developed, many based on tools developed for the business market. Though smaller in number than the new drill-and-test courseware and educational games, these tools will be easier to use in instructional settings, and therefore will have a significant impact on education, out of proportion to their numbers.

Such tools as word processors, graphics and animation editors, data

management tools, spread sheet programs, and music tools will become "friendly" enough to be used even by novices. The number of different word processors for microcomputers is now in the hundreds, with specialized systems appearing aimed at novice writers (the Bank Street Writer and the Writer's Assistant). We will see such specialized word processors integrated into the writing and reading curricula.

Many of the valuable features of general purpose programming languages will also appear in specialized tools. For example, the notion of a procedure (actions bundled together to create a more global action) appears in existing music tools in a context easier to understand than when presented in general purpose programming languages. A packaged sound pattern, modifiable through parameters, is much easier to understand through music than a repeated invocation of a sequence of abstract data manipulations.

As another example, the notion of conditionality is much more graphically presented in tools like Rocky's Boots (a system for teaching children electronic design) or the Pinball Construction Set (a graphics/programming tool for creating and editing video pinball games) than in a BASIC language IF-THEN statement. The same holds for all the other valuable constructs that are contained in programming languages. As a wide range of special purpose tools are developed, the instructional utility of general purpose programming languages will diminish substantially.

The Role of The Site Administrator

The principals at each of the six sites, though operating in quite different environments, were similar in several respects. None claimed to

possess extensive computing knowledge themselves or saw the need for other administrators to gain such expertise. But rather, each emphasized the need for administrators to have an open attitude towards change, to try to anticipate future trends in society and most importantly, appreciate the growing importance of computing skills to the students of today. They were unanimous in their praise of their teachers, who were delegated a great deal of responsibility for curriculum development and hardware selection. The identification of interested and motivated teachers was considered by each administrator as fundamental to program success. Community interest was also considered as an important factor in initiating interest in the computer program.

Policy Implications

The following policy implications for the Teacher Education and Computer Center are derived from the observations made in six exemplary classrooms and other studies reviewed in this report:

1. Programming should no longer be considered as the primary entry point to computing literacy. Though computer supported drill has been shown somewhat effective in remediation of basic skills, the vast majority of students will benefit from the early introduction of a range of powerful, special purpose tools. Widespread implementation at CAI is unlikely to be cost effective over the next few years. Learning to program using a general purpose computer language will play an important role for only a relatively small number of students. Therefore, learning to program should not be used

as a means to restrict access to other computer uses.

2. Multiple entry points should be identified for elementary and secondary students. Editing in various contexts is increasingly employed as a means to introduce novice students to computer technology. Text processing, music composition, graphics design, animation, data base management and spread sheet analysis software are all available for popular microcomputers. A new class of tool-type software like Bill Budge's Pin Ball Construction Kit or TLC's Rocky's Boots can also serve as an environment for novice users to develop fundamental computing literacy skills.

3. Computing literacy skills should be applicable to a wide range of software and languages. Concepts of editing, debugging, conditionality, control and recursion, variables, functions and procedures should be addressed in a range of contexts. Such "topdown" approaches to literacy demonstrate the relevance of various skills and lead to transfer among contexts.

4. The TEC Center should play a central role in evaluating and distributing public access and commercial special purpose software tools for common microcomputer systems.

5. The TEC Center should consider coordinating an effort to open classrooms of teachers currently using computers in particularly effective ways, to visitations by other interested educators. The cost of such support should be minimal since "model" classrooms are already functioning. Only publicity, scheduling and some additional technical and personnel support

would be required.

6. The TEC Center should take the leadership in establishing a telecommunication network linking key schools, district curriculum personnel and institutions of higher education throughout the service area. Initially commercial networks like the Source or Compuserve or an electronic message system at a local university could be employed. Establishing a county wide system using a small main-frame computer housed at the county office should be explored. The purpose of such a system is to enhance communication via electronic mail among computer users, support formal and informal inservice activities and eventually allow the efficient transfer of software.

7. The TEC Center should coordinate the production of a series of classroom computer use inservice films or tapes focusing on program development, reviews of exemplary sites, classroom management, uses in special education, software evaluation, hardware solutions and administrator training. A recent Department of Education production, 'Our Computer Story', is an example of such a tape in the content area of writing. The UCSD study mentioned above plans to produce tapes of this sort on the process of introducing computers into classrooms.

8. Special workshops designed to familiarize school principals with effective classroom and administrative uses of computers along with a systematic means for supporting the development of school/district computer literacy programs should be designed and implemented by the TEC Center. With increasing interest in computer related programs in all school districts, it is important for administrators to be aware of the efforts of other local program development efforts as well as gain a basic understanding

of computer capabilities to aid them in making programmatic, personnel and budgetary decisions.

9. The TEC Center should continue to assist with and when necessary, coordinate computer inservice courses for teachers and administrators throughout the service area, focusing primarily on software tool applications, classroom school/organization, software evaluation and curriculum development.

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Exemplary Computer Use in Education

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Laboratory of Comparative Human Cognition

The educational system is faced with the challenge of integrating computers appropriately into its daily activities. Schools are under considerable pressure from parents, politicians, economic and academic leaders to introduce computers in the curriculum. While resources for purchasing computers are provided by grants and fund raising activities, the education system is left to provide the content (what should be learned about computers), the form (how to learn it) and the technical and academic support to enable educators to implement a curriculum that includes computers.

Several researchers have reported recent surveys on computer use in schools (Shavelson, 1981; CSOS, 1983; Tucker, 1983; CUSG, 1983). In the project described here, we set out to find exemplary uses of computers in classrooms. We conducted an in-depth study of six exemplary classrooms in the San Diego County area, in order to identify the salient features and the critical aspects that contribute to exemplary computer use. Our intentions were to identify the range of characteristics likely to lead to successful use of computers in the classroom rather than describe normative cases.

The selection of exemplary sites could not be based on an a priori

predetermined model of how schools should use computers because of the lack of agreement on what the ideal model should be (Papert, 1980; Johnson, Anderson, Hansen & Klassen, 1980; Luehrmann, 1981; Anderson, Klassen & Johnson, 1981). It was also unclear whether there was an accepted, de facto, notion of an "ideal" computer use in the school system. Therefore we decided not to use any specific attribute of computer use in the schools, nor the similarity or dissimilarity among schools. Instead we decided to rely on the logic of anthropological research. Anthropologists seek the advice of local experts to point them to features of the environment considered by them to be most important. In our case we approached key educators, and asked them to identify local schools recognized as being exemplary users of computers in the classroom.

Potential sites were suggested to us by the resource teachers from the San Diego Teacher Education and Computer Center. The sites seemed well known to the group and there was clear agreement on the final selection. These teachers seemed comfortable in pointing out exemplary cases they had contacted within their region. We were struck, however, by the fact that each time these informants proposed a new school, they used a different set of criteria of excellence. One school was identified because it provided sound training to students for the job market; another for the motivation and dynamic nature of the teacher; a third for its widespread use of computers throughout the school and another for the level of programming skill achieved by students. We selected six of the 14 schools proposed by the resource teachers. The selection was based on geographical representation of the regions within the county and on the grade levels in the schools (2 elementary, 2 middle-school and 2 high-schools).

Four interviews and eight observations were carried out in each school during the Spring of 1983 by undergraduate students participating in a Computer Literacy course at UCSD. Each student received brief training in interview and observation methods and was assigned to one of the schools. A detailed observation schedule and interview guide was prepared. To provide a check on reliability, one additional student made independent observations in all six schools. A series of follow-up interviews of administrative personnel at each site is planned for the Summer of 1983. The following issues were addressed:

- Methods of introduction of computers to school
- Parental and community involvement
- Arrangement of computers in the classroom and the school
- Availability of computers and student access
- Hardware and software choices, problems and solutions
- Computer lessons, preparation and execution
- Integration of computers into curriculum
- Technical support required and sources available
- Impact of computers on students and teachers
- Projections for the near future

Descriptions of the Six Sites

Eucalyptus Elementary School services about 400 students in grades K-6. The students in the exemplary classroom were in grades 3, 4, and 5, and were selected by the teacher based on an application by parents. The school had one Apple II computer, housed in a movable cart, which is located most of the time in the back of the exemplary classroom. The students engaged in a range

of activities, including word processing, real time communication with special education students in another school, data base management, graphics and animation, and programming in BASIC and LOGO. Students were scheduled to use the computer in pairs throughout the school day, while the other students were engaged in whole class lessons with the teacher. Occasionally the students rolled the computer to other classrooms to provide computing experience for the rest of the school.

The second classroom was at Ebony Elementary School, a district-wide "Computer Magnet." The teacher used twenty-three Apple II computers, interconnected in a "local network" in a "computer lab" setting. Other teachers in this school scheduled their classes into the computer lab once a week for thirty minutes. The computer teacher then conducted the lessons in the lab, focusing more than 90% of the time on LOGO programming. The rest of the time he used social science simulations and educational games. The teacher had the responsibility for providing computing experience to all of the K-6 students in the school.

Maple Secondary School was a district-wide Math, Science and Computer Magnet. The classroom observed serviced grades 7-9. The school has over thirty Apple II computers, eight Pet computers, and thirty-two terminals to a main-frame computer. The teacher focused on BASIC programming, building on algebra as a prerequisite and leading to FORTRAN and Pascal programming at the senior high level. Seventh and eighth grade "magnet" students worked with the computers during a two week period each month. The ninth grade magnet students worked with the terminals during the whole school year, working in pairs for fifty-five minutes each day on BASIC programming.

Mahogany Middle School was the second middle school program observed. This classroom serviced all sixth grade students and elective BASIC courses for some seventh and eighth graders. The school used twelve VIC-20 computers (interconnected in a local network), and two Apple II computers, located in a computer lab setting. The two Apple computers were occasionally rolled to other classrooms for demonstrations. All sixth grade teachers scheduled their classes into the lab one hour a day for 9 weeks, where they were taught by the computer teacher. The curriculum, prepared by the computer teacher, consisted of a series of short BASIC programming exercises. Students worked in pairs at their own pace.

At Hickory High School, the fifth site, the computer literacy program was developed by members of the Business Department faculty. The course consisted primarily of word processing, and BASIC programming with some data processing instruction. The business classroom used twenty-three TRS-80 Model III computers. The computer teacher's goal was to provide writing and other job entry skills to the largely minority students in this school. The teacher had five classes of about thirty juniors and seniors each day. The students used the word processing in this business course to write their English compositions and other writing for their classes.

Hemlock High School was the final site observed. This school was situated in a fairly affluent area. The computer lab had thirteen IBM Personal Computers and one Apple computer. The teacher taught three courses in computer literacy and also supervised periods of independent use. The curriculum focused on the use of a wide range of computer tools such as word processing, electronic spread-sheet programs, graphics and animation editors, simulations, data base systems, and some BASIC programming.

We found computer activities in these six schools that are among the least commonly found in other schools throughout the country. For example, four of the six schools observed (the elementary and the high schools) used their computers to teach word processing (among other things). According to the National Survey of School Uses of Microcomputers, word processing is used in only 3% of the elementary schools and 7% of the secondary (CSOS, 1983). Demonstrations, problem-solving using programming and recreational games were the other common uses in the schools we observed, while at the national level they were found regularly in only about one-fifth of the schools with microcomputers (CSOS, 1983). None of the exemplary schools we observed was engaged in systematic drill and practice use of computers, which occurs in 59% of primary and 31% of secondary schools in the country.

In general we found that these schools are responding to the computer challenge by encouraging diversity of use and content, relying on unconventional resources and support and settling for heterogeneous criteria of success.

Diversity of Use and Content

The most visible aspect of the use of computers in the six observed sites was the tremendous diversity of implementation and the implicit acceptance of this diversity as legitimate. The hardware and software available in schools, the accessibility of computers to students, the activities and content considered appropriate, the arrangement of computers in the classroom and the structure of lessons, all varied across the classrooms.

The diversity and incompatibility of hardware among schools in itself is not a new finding (Miller, 1983). Availability of funds, personal experience of teachers and constraints from the sources of funding are the obvious reasons used to account for the differences. The diverse attitudes of teachers towards the different hardware, on the other hand, are somewhat surprising. Some teachers intentionally expose their students to different computers and terminals while others avoid using more than one model. In two schools different models were used with the same students for different activities; in another school students were assigned to different models according to their skill: the most advanced students got access to the more expensive machines while the rest of the class used the less expensive machines. Since there were some technical problems with the less expensive machines (a network system for loading and saving programs was not working although it was supposed to be functional more than a year before) only the few students working with the expensive machines were able to save their programs and revise them later. The other students lost their programs when the machines were shut off at the end of the class.

We also found diversity in the quantity vs computer-cost choice: some schools preferred fewer machines of a relatively expensive model while others preferred the opposite. This difference does not seem related to the absolute amount of funds available: one (affluent) school has 13 IBM Personal Computers while another (less affluent) school, with roughly the same number of students per class, has 20 IRS-30 model III machines. One elementary teacher (in a less affluent school) used funds to acquire a single Apple II while another school in a more affluent neighborhood preferred 12 VIC-20 which are about 1/10 as expensive as the Apple II.

Diversity in software used, activities allowed and "appropriate" topics parallels the diversity in hardware. There are big differences in the extent to which commercially available software was used as opposed to software provided by the district or created by the teachers and/or the students. In the classroom that used LOGO 90% of the time, students use specific procedures in LOGO, programmed by the teacher, in order to create artistic drawings. Once printed, the drawings were displayed on a special bulletin board. The other elementary teacher taught his 4th-5th grade students to use a commercial data-base program to print attendance lists for the school office. These students also regularly used a communication program to interact with handicapped students in another school using the computer and a telephone line.

In one of the middle schools the teacher allowed "arcade-type" games in class but only at the beginning of the year or after-school hours. In the other middle school the only commercial software available were drill and practice programs which the teacher disliked. Therefore the class used only programs developed by the teacher or the students. In the two high schools, the main activities were centered around applications of commercial software but there were differences because of budgetary constraints. In the more affluent school, students had access to a wide range of application software including graphics, music, word processing, data-bases and spread-sheet. In the other school students worked primarily on word processing due to budget limitations, however, there were plans to buy data-base and spread-sheet software following year.

Three of the schools stressed the importance of programming, while in

the other three programming was not considered the necessary (and certainly not the best) entry point to computer use. One elementary teacher used LOGO, as described above, to teach programming procedures to children from kindergarten to sixth grade. The other elementary teacher used programming only as one of the topics of computer use. He used both BASIC and LOGO as examples of programming languages. He used another specialized program to create graphic designs. This teacher invited the undergraduate observer from our project to give a lesson on Pascal programming to the 4th graders and to discuss with them the differences among programming languages.

The two middle schools used BASIC as the programming language. In one of them the activities were traditionally structured: first an introductory course in algebra, then programming in BASIC, then in high-school students learn programming in FORTRAN. After completing these courses, students can take Pascal as an elective. The other middle-school teacher created his own booklet with problem solving exercises in BASIC dealing with arithmetic, language and graphic design. The two high schools didn't focus on programming as their main activity but instead stressed the use of software tools as preparation for the students' immediate future: college or the job market.

At present, diversity in computer-use in schools is the rule rather than the exception. All the teachers interviewed described having freedom of choice concerning the form and the content of computer classes. Most of the teachers knew their activities were different from classes at other schools but weren't bothered by the disparity. Moreover, everyone expressed interest in knowing more about other schools, looking for useful ideas to implement in their own classrooms. Even the secondary school with the most traditional

approach (algebra, BASIC, FORTRAN) had just set up a new class with a different approach (more use of commercial software tools and much less programming).

Diversity in curriculum is not currently a general property of the conventional educational system. The movement is toward highly specified and centrally controlled curricular materials. Textbooks and district guides are generally specified using well defined goals and objectives. Often topics to be learned are carefully coordinated with specific teaching methodology. Standardized tests are considered objective verdicts of success or failure. Curriculum innovators often refer to the "problem of program implementation," meaning the variability ("distortions") found among different sites when implementing a new program. This variability, often attributed to teachers, is usually considered a hindrance to the effect of the new program (Hall & Loucks, 1977; Fullan & Pomfret, 1977).

In the case of educational uses of computers, diversity seems to be instrumental. These innovative teachers are inventing effective ways to implement the use of computers in their instruction. Teachers currently are not told "here is a computer, a curriculum and a teaching method" but instead they are provided with computers and then queried about their use and effectiveness. If we take into account the rapidly changing technology of computers, it may well be that variability is the only way to generate the innovative approaches required to effectively use computers in education. More rigid strategy may be counter productive in the long run.

Unconventional Resources and Support

There was considerable reliance on unconventional and informal resources of support in all the schools observed. Teachers relied on friends or personal contacts to solve technical and management problems. Commercial computer magazines were consulted to identify high quality educational software. Teachers and principals approached businesses and research funding agencies to "adopt" or support school computer facilities.

Most of the teachers spent many unpaid hours at school either with students or preparing materials for computer classes. All the teachers stressed the importance of teacher motivation as a key factor in the effect of computer-use on learning in school. Older students and parents were mobilized to serve as aides in computer classes. The parental interest at two of the schools was so great that some who volunteered to assist in the computer classes had to be turned away. All the teachers spent extra time trying to keep their knowledge up to date, participating in conferences and computer-user groups, making professional presentations of their work and introducing other teachers to computers.

The reliance on unconventional resources for support is not a criticism of district inservice personnel. It would be more appropriate to say that:

- The help required is extensive and diverse: technical assistance (hardware), appropriate materials (software and documentation) and in-service training.
- Help is readily available from sources outside conventional district

support facilities: it's easier and not unreasonable to ask a personal friend how to use a modem or interface a tape-recorder; it's easy and practical to take the faulty disk drive to the nearest computer store; a monthly computer magazine will always be more up to date with the latest developments on software than will a district publication; the newest and most attractive software is likely to be available on the store's shelves.

- Financial support may be easier to get outside the educational system. Even in the current state of economic uncertainty there is willingness on the part of community agencies, industry, parent associations and research institutions to support the purchase of computers for schools. These outside channels of support are attractive in times of fiscal austerity since they provide a feasible alternative to the shifting of resources within the school to provide funds for computer implementation (and thus avoid the potential resentment). Also, when teachers and administrators succeed in attracting this type of support, they gain status within the school and the community.

Heterogeneous Criteria of Success

The teachers were asked to assess what they regarded as their main achievements. One pointed to specific preparation for the job market, high enrollment for next year's courses and reduced absenteeism. Another indicated that due to experience with computers, students were excited by school and worked harder in all their classes. One high school teacher referred to his primary goal in the following manner:

"The students are now comfortable with the computers, without the awe and intimidation felt by many. They are aware of computer capabilities, and may now be able to see a real world problem and know that a computer would be able to help to solve it . . . stressing the viewpoint of future computer users, not just programmers."

Others pointed to the programming capabilities of their students, the teachers' renewed interest in their work, the "Hawthorne effect" (improved performance resulting solely from the fact that a change, any change, in the environment was made) on teachers and students, remedial learning, mutual help among students and independent and self paced learning.

Of the six teachers interviewed, only one expressed surprise at being chosen as an exemplary case. Most of these teachers have been exposed to a constant flow of visitors and to some extent "admirers." Teachers like these are often tapped for higher status positions within and outside the education system. Several have been the subject of newspaper articles and their classes have been filmed. A recent film on computer supported writing featuring four different classrooms (one of which was in our sample) has been produced by a local education authority and is being distributed throughout the State of California for inservice purposes. The teachers involved know that their work and achievements are valued by society.

In each case it seems reasonable to accept their heterogeneous achievements as valid. However, it is important to note that different and somewhat diffuse criteria are used to measure success. Improvement is not measured on standardized tests, nor are systematic comparisons with control groups made in order to control for "placebo" or "Hawthorne" effects. We, as well as the teachers, parents and administrators, accept different and sometimes even opposing achievements as legitimate. Some students learn to

program in LOGO, BASIC or Pascal while other learn to use software tools like word processors, spreadsheets and data bases. It may be that the only discernible effect of computer-use is on student general motivation to school or in the social organization of learning such as improved teacher-student relations, more independent work or mutual help among students. This lenient approach to evaluating success is not the usual case in schools for other subjects where requirements are often more constrained, well specified and systematically assessed.

What can we learn from these observations? Schools are faced with the challenge of effectively integrating computers into the learning process. These exemplary cases are responding in a manner of "evolution by natural selection:" developing variation, facilitating replication and striving for survival in a technologically dynamic environment.

In the schools observed, there was a clear tendency for teachers to devise their own program of study involving computers, programs that were closely related to the teachers' own skills and personal interests. A teacher's personal interest is extremely important since the teacher will be committing many unpaid hours to keeping up to date on hardware and software developments, designing curriculum and support material, and sharing the expertise with colleagues. The specific form of computer use in each school will also depend on anticipated employment requirements, parental expectations, funding constraints and the availability of technical support. Accordingly, each school will set up their own norms of achievement, which will not necessarily be consistent with other schools.

Successful programs survive by being selected for implementation by

other teachers and by being adapted to new technologies. Newcomers to the implementation of computers in education search for attractive uses to adopt in their own classrooms. Since they have some degree of freedom they become the key for the survival of the best forms of use. Thus computer "buff" teachers have become the critical "grassroots" factor in adapting the use of computers in schools to current technological developments.

The continuous development in computer technology and the diversity of equipment available in the schools are natural barriers which these successful implementations have to overcome. Because of the technical incompatibility of the various computer models and the relatively short life span of the machines, computer literacy should not be limited to hardware with very specific characteristics. Teachers' awareness of this problem encourages them to keep developing and broadening their expertise.

If the implementation of computers in education followed the traditional top-down hierarchical approach, it could not keep abreast of the rapid technological changes and might become overly constrained in its application. Using a traditional approach to curriculum development, district level personnel would arrange for systematic evaluation in order to decide which specific type of use to recommend for various groups of students. They would next design curriculum and supporting teaching materials, arrange inservice and proceed with the introduction into the schools. The amount of time for changes of this type to be introduced would be too long to take full advantage of current technology. By the time the chosen approach was installed in the schools, it would likely be outdated.

The current diversity of accepted implementations, the less rigorous

definition of what counts as achievement and the availability of unconventional support and resources, together form a protected environment in which teachers are able to experiment with the use of computers in their work, create new forms of use and keep up with the rapid technological change. The immediate effect on classroom instruction seems to be an increased involvement on the part of teachers and more enthusiasm from the students.

We also found that the activities in these schools are among the least common found in other schools throughout the country. If we consider the exemplary status and the visibility that these schools enjoy, our findings may point to future trends in computer use in classrooms: more word processing and other computer supported tools, a decrease in drill and practice and a reduced emphasis on programming as the primary skill associated with computer literacy.

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This paper will appear in The Newsletter of the Laboratory of Comparative Human Cognition, Volume 5, Number 3, University of California, San Diego. This research was supported by the Teacher Education and Computer Center, San Diego and Imperial Counties. Special thanks to Jerry Ackerman, Eva Bustos, Alison Cohen, Caroline Ferreri, Claude Gigoux, Qarin Van Brink and Kathleen Ward for conducting the observations and interviews and the teachers and students from the six school sites who graciously shared their experiences with us. Also many thanks to James Levin, Randall Souviney, Margaret Riel and Bud Mehan for their many useful comments on earlier drafts of this paper.

APPENDICES

APPENDIX I

Summary of Exemplary Computer Use Sites

The following section presents a summary of the six school sites reported in study, "Exemplary Computer Use in Education." To assist the reader, the summaries are organized in two ways:

1. A general description of the most salient characteristics of each site.
2. A systematic comparison of the sites according to each of eleven observation categories.

Site Summaries

Eucalyptus Elementary School. The first elementary school services about 400 students in grades K through 6. The class was a combination of third, fourth and fifth graders. Parents applied for their children to be enrolled in the school's computer program, and the teacher selected among the applications to fill the thirty positions in the class. These students receive instruction in standard elementary school subjects, but are also exposed to the school's Apple computer under the teacher's guidance. The school has only one Apple II computer with two disk drives, a color monitor, and an Epson MX-80 printer housed in a lockable, rolling 'Apple-cart'.

In the classroom, the students were taught a variety of subjects with the computer including word processing, graphic arts, computer science, BASIC and Logo programming, creative writing, database management, and animation. The lessons were presented to the class as a group, with the students gathered around the computer as the teacher talks. When the lesson was complete, and all questions were answered, the students took turns completing a short exercise using the knowledge gained. Each student chose a partner to work with when his turn arrived. This switching process went on during classes throughout the day, without disruptions and continued until all students had a chance to try the exercise.

In addition to these lessons, the more motivated students were given special projects to work on, such as using the computer's card reader and scoring program to tally the survey results of the recent CUE conference which were filled out on scan-tron cards by the attendants. A database of all the students in the school was also maintained by the class. About twenty pieces of information on each of the students attending the school were stored and could be recalled at any time by the office personnel when needed. Other projects, like word search and cross-word puzzles were generated by the students under the direction of the teacher and were actually used in class to aid teaching.

Students also volunteered to 'talk' with students from another school via a communications program and a modem, sending messages back and forth

to each other over the phone lines. The other school called daily, and an attempt was made to give every student a chance to communicate with the students there. Writing projects were designed occasionally and gave the students a chance to make use of their word processing skills. Term papers and writing assignments were usually written first on paper and then transferred to the computer for revision and editing. When the teacher did not have a computer lesson available, or the class had some extra time, the teacher occasionally permitted the students to work on whatever they wished in the rotating pair scheme mentioned earlier. Each group got 30 minutes to an hour per week and often used the time to do programming, creative writing, art, or catch up on work they have fallen behind in. Their progress is checked occasionally by the teacher to insure that they are not just "goofing around", but are doing something constructive.

Ebony Elementary School. The first two computers (Commodore Pets) were donated to the school by a parent. The teacher was the only one to show interest in the computers. He and the Principal worked together in exploring the possibilities of a computer program as part of the Magnet project. Approval of this proposal provided funding for the purchase of the Apple Computers and software programs used now. Initially money was collected from any available resource, including paper drives. After the Magnet grant was provided the teacher had a free hand to structure a computer program.

The teacher designed one basic curriculum for all grade levels Kindergarten through sixth, based mainly on LOGO. He advances at different rates to accommodate the different abilities. Most lesson preparation is done for the sixth graders and the kindergarten classes. The other classes fit somewhere in between. The teacher used the five minutes between the classes to look over what the class did the week before and to decide whether he would have the students continue on last weeks work or introduce a new topic. All students at this site were required to spend 30 to 40 minutes per week in the computer room as part of their curriculum. The computers were available before school, during lunch and after school on a sign-up or drop in basis. The students who utilize this availability were usually the fifth and sixth grade boys. Time is split between working on class projects or outside recreational material. The teacher no longer allowed arcade games. There were usually ten to fifteen students in the class during these times. Primarily computers were used "to improve general thinking and problem solving skills." The aim was not to limit computers to a particular use but to provide the students with a tool that will help them in a variety of situations.

The teacher was constantly working to discover new uses to share with his students. He had the school buy a new light-pen device (Gibson Light Pen Graphics System) which he hoped to integrate with his curriculum. He is also interested in word processing and networking between schools. The teacher chose these programs based upon reviews in software magazines. Logo was the basic tool for instruction and was used to run a variety of programs that the teacher wrote. Other software, used to a much less extent, includes Meteor Math, Bankstreet Writer, The Menu, Lemonade, Odell Lake and Oregon Trail. The teacher felt that all that is needed for a successful curriculum is Logo and a creative writing program. He would like to have access to the interactive word processing system developed at UCSD but indicated it does not currently run on his network system.

Some donated hardware was not being used since it was outdated or required extensive repair. Another technical complaint was that the network system-software to support Pascal software was supposed to be available more than a year ago but it isn't ready yet.

Maple Secondary School. The classroom which we observed was part of a 7-12 "math, science and computer magnet" secondary school and services students in grades 7-9. The school had 32 terminals attached to a DEC-PDP1160 mainframe computer, 30 Apples, 8 Pets, and 2 Telemath machines. There seemed to be little problem with the purchasing of additional hardware. The school board has been very supportive due to the current, court-ordered desegregation mandate and the school will get more computers next year.

The computer program emphasized programming in various languages. The seventh and eighth grade students were introduced to the computers and wrote their own simple programs. The ninth grade students learned BASIC and the high school students learned Fortran. Senior high students also had the option of taking Pascal or Assembler language. Computers are currently reserved for students in the Magnet program though plans are underway to include the resident students in "computer literacy" instruction next year (1983-84).

The computer activities began by using exciting programs to get the younger students interested and motivated. Math, random numbers, and graphics were introduced to the students as they progressed. Evaluation was done by written tests and by checking the programs the students were doing on the computer. The teacher indicated that the distribution of computer use was: 50% motivation, 25% introduction, 2% instruction, 20% practice, 2% examples, and 1% evaluation. The goal was to give a good, solid background in programming computers before the students reach high school and college.

In the seventh and eighth grade students spent every other week working on the computer. The rest of the semester they moved to another classroom to concentrate on math and science. The ninth grade students concentrated specifically on BASIC. The teacher prepared about fifteen lessons a week. Some lessons were prepared two weeks in advance, and others the night before. Sometimes she used the previous year's lessons. She usually took about thirty minutes to prepare the exercises for the seventh and eighth grades. Altogether, it required about ten hours of outside planning a week.

The lessons for the seventh and eighth grade classes were introduced with worksheets. The lessons were often introduced or reviewed with the overhead projector. The students worked for about ten minutes on the worksheets. Next, they wrote a program in class with the help of examples, then spent 20-25 minutes on the computer itself. The ninth grade students took lecture notes and spent 30-35 minutes on the computer.

Mahogany Middle School. All of the observations for this report took place during the 6th grade required computer literacy classes. In addition to these classes, the teacher also was responsible for teaching computer programming as an elective for 7th and 8th graders and GATE students. The 6th grade homeroom teachers accompanied their students into the computer classroom and remained there during the entire period, serving as teacher

assistants. In addition, there was a parent volunteer who assisted in the classroom as an aide, and a "peer" t.a. from the 7th or 8th grade who was classified as a "programmer." The student/teacher ratio was 7/1. The computers were located around the exterior of the classroom. There were generally two students per computer.

During the lecture time, the students sat at the long tables in the center of the room. There were a total of 14 computers in the classroom--12 Commodore VIC20s and 2 Apples. The VIC 20s were arranged along three of the walls, 4 per wall, on long tables. The two Apples were on moveable carts so that they could be taken out of the classroom and used as tools by other teachers in their classrooms.

Computer literacy has been integrated into the regular curriculum of the 6th graders as a required class. The teacher wrote the manual for the computer literacy class. For any given week the teacher spent 1 to 2 hours per week "lining up what to do" in the class. Much of the planning time was spent in modifying and supplementing the workbook to meet the specific needs of the students. Each student spent an average of 25 to 30 minutes per day on the computer.

The teacher used the computer to introduce and instruct the kids in a new concept by having them work through their notebooks at the computer and later reinforce what they had learned through large group discussion. Because students worked at their own pace, not everyone was working on the same assignment at the same time. This allowed the instructor a little more flexibility in tailoring the lessons for a large group while allowing him to work with students on a more individual level. The learning activities in the computer literacy class included: large group lecture/discussion, small group computer use time, student reports, and testing/evaluation.

The teacher had the responsibility for the evaluation and selection of software for the school. He used a system which was printed in the October 1982 issue of the magazine "Electronic Learning" as criteria for choosing software. He did not use commercial software as curriculum materials for computer literacy. He did recommend a few pieces of software which he considers to be quite good: "Oregon Trails," "Division Derby," and the Millikan Math Series. These are simulations with "embedded" tasks and are very motivating learning activities. The teachers complained that the networking system did not work as he had anticipated since the children cannot save their work by loading it to floppy disks. Therefore, when they turn the computer off, their work is lost. In addition, they are unable to use the software written for the VIC20 computer system since it is configured for individual disk drives or cassette recorders.

Hickory High School. This classroom was part of a "magnet" program at the school, designed to attract students from outside the service area to reduce racial imbalance within the school. The course, Computer Literacy I, was an elective in the Business Department curriculum. The class was composed of 33 grade 11 and 12 students and a teacher's aide. The basic goals of the class involved the development of: word-processing skills, basic programming skills, data processing skills, and a strong knowledge foundation of computer history, and the social and ethical implications of the computer revolution.

The 1982-1983 school year was the first year of the computer literacy

program at the school. The primary person responsible for the introduction and implementation of the program was the principal. He suggested the creation of the computer magnet in order to attract outside students and to meet a pressing need in the community to prepare students for employment. The computers used in this program were bought under Title 4B--Desegregation and Vocational Funds. There were a total of 33 computers in the school: 23 in the business department, (observed in this study) and 10 in the math department. All of the computers are Radio Shack TRS-80 Model III Microprocessors. The math department computers were bought under Title I Funds for remedial students. These computers are mainly used for drill and practice of math lessons.

The ideal model for the computer literacy program, shared by both the business department and teacher, was the graduation of students from the program with marketable computer skills and a sense of job readiness. The goal was to meet the needs of the community, since a large percentage of the students were not likely to continue onto higher education, but rather enter the job market. (The school population was 83% minority with about two-thirds of the families on welfare.)

Another explicit goal of the computer literacy program was the improvement of writing skills. For this purpose, the teacher coordinates written assignments with the English Department. The integration and coordination of assignments between teachers in various departments was seen as critical especially with English as a Second Language (ESL) students.

The teacher had five computer classes per day. During one semester, the teacher planned from 7 to 10 assignments which required from 2 to 10 hours of preparation time. Besides this time, one hour per week was generally necessary to prepare the physical environment for an assignment (arranging diskfiles, moving relevant material). The teacher presented new concepts and programming statements using an overhead projector and chalkboard. Then students moved from their desks to the computers. Students were given assignments which required the use of new concepts and programming statements. Evaluation of the assignment followed which included an output and listing of the program, running the program for the teacher and an oral evaluation by the teacher. The teacher supervised all class activities by circulating among all students, both in the computer area and in the desk area.

Hemlock High School. The school, build around a media center with two academic wings, serviced grades 9-12. The school had a philosophy of individualized instruction, following the Keller Plan, and the classrooms were set up in a somewhat informal manner. The computer center was opened in the Fall of 1982 with California State Department of Education, School Improvement Project (SIP) funds. An active group of parents and the principal were primarily responsible for the introduction of computers to the school. A task force of parents compared the advantages of different computer models and finally recommended the IBM Personal Computer. This decision was strongly influenced by the parent group involved in establishing the program. The district provided funds for remodelling and a security system for the computers.

The teacher was responsible for teaching three courses in computer literacy, leaving time for unscheduled student access during the remaining class periods. The computer center had thirteen IBM PC's with two disk

drives each and one printer per four computers. There was also one Apple II+ with a disk drive and graphics tablet.

The lessons focused on a range of tasks associated with computer literacy. The objectives addressed the uses of computers and the problems they can solve. Included were lessons requiring the use of spread-sheet software, word processing, data base management, graphic design simulations like Flight Simulator, and a brief introduction to video games. The teacher began the class period by lecturing briefly about the current assignment which was generally associated with some software tool. The students then applied the tool to the assigned task. (e.g., each group invented five people, their addresses, and their blood type, and then entered the information into a Visifile--a data base management program--to carry out various selections.) During the free-use periods anyone in the school who has the period free is welcome to come in and use the machines. Students come in to use the various software tools such as a word processor to write papers for other classes and other programs.

The computer center has had a major impact on the school at large. Students are becoming more familiar with computers and are using them to carry out a range of assignments in other classes. As a possible side effect, students seem to be losing interest in some of the other technical electives as auto-mechanics and wood-working. The demands on the computer program are increasing rapidly. There are plans to acquire additional computers for use in the departments of Mathematics, Journalism, Foreign Language, Social Studies and Business. Teachers in these departments have expressed interest in developing the technical skill necessary to integrate computers into their daily instruction.

Summary by Observation Category

The following sections summarize the observations at each of the six exemplary sites according to the following 11 categories:

1. Introduction of Computers Into the School
2. Parental and Community Involvement
3. Computer Lessons and Preparation
4. Availability and Access
5. Physical Arrangements
6. Integration Into Curriculum
7. Hardware Problems
8. Software
9. Support
10. General Impact
11. Teachers' Views of the Near Future

1. Introduction of Computers Into the School

Eucalyptus School - The teacher convinced the school that a computer and a corresponding program would be a good idea. Under the School Improvement Plan, the school was able to purchase one Apple II computer with associated peripherals (disk drives, printer, color monitor). A portable, lockable cart was also constructed by school staff to allow the computer to be wheeled where it was needed, though control of the equipment would be the responsibility of the teacher and requests for

its use would go through him. The main location of the computer cart would be in his classroom where it would be used by him and his students as an educational tool.

Ebony School - The first two computers (Commodore Pets) were donated to the school by a parent. The teacher was the only one to show interest in the computers. He and the Principal worked together in exploring the possibilities of a computer program. The principal was primarily responsible for drafting the proposal for the Magnet project. Approval of this proposal provided funding for the purchase of the Apple Computers and software programs used now. Initially, money was collected from any available resource, including paper drives. After the Magnet grant was provided the teacher had a free hand to structure a computer program. After the original money ran out no more was available, and the initial purchases are going to be sufficient for the immediate future.

Maple School - The school was originally a junior high school, but was expanded a few years ago to include high school students and the Math, Science and Computer Magnet Program. The Magnet Program was set up specifically for teaching computer science and programming. A district sponsored "magnet school" committee consisting of parents, school personnel, university faculty and other community members, were responsible for establishing the program. The equipment was bought with Title I, Federal ESEA Integration and Magnet funds. The school board has been very supportive. The program continues to grow and plans to purchase more computers next year.

Mahogany School - The program at this school developed as a result of a district-wide effort to establish guidelines for computer literacy in grades K-12. The teacher in Mahogany School has been instrumental in designing the computer curriculum for the school computer literacy classes and programming electives. He has recently purchased Pascal system software so that the language can be offered to the GATE students. He is currently helping one of the instructors write a grant for a word processor, and has solicited various companies for donations of computers. The school would like to have at least one computer in each classroom in addition to the computer lab.

Hickory School - The 1982-1983 school year was the first year of the computer literacy program at the school. The program was conceived by the Business Department faculty and the site principal. A plan was developed to create an International Business School Magnet with a strong computer use component to attract outside students and meet a pressing need for employment training for the students in the community. The hardware for the computer literacy program was bought under Title 4B desegregation and vocational funds. There were a total of 33 computers in the school: 23 in the business department, (chosen as one of the exemplary classrooms) and 10 in the math department. All of the computers are Radio Shack TRS-80 Model IIIs. The math department computers were bought under Title I Funds for remedial students. These computers are mainly used for drill and practice of math lessons.

Hemlock School - The computer center in this school was opened in September of 1982. It was created using School Improvement Project (SIP) funds in 1981. The principal and a group of interested parents were primarily

responsible for the introduction of computers to the school. A task force of parents compared the advantages of different computer models and was successful in its efforts to encourage the district to purchase the IBM Personal Computer. The district provided funds for remodelling and the security system for the computers.

2. Parental and Community Involvement

Eucalyptus School - Parents must request that their children be enrolled in the computer program. There was one parent who came before school one day a week to work on the computer with his child. The community had not been involved in the computer program except for a group called the Mott Foundation who donated funds for a modem for the school's computer. The teacher was working on an Adopt-a-School program with some of the local computer businesses which will hopefully have the effect of increasing the community involvement with the school and provide both technical knowledge and equipment for the computer program.

Ebony School - Parents were highly involved in establishing the original program. Since that time, although input has been positive, interest has waned. A few parents have volunteered to serve as aides, although lack the experience to really help. Continuing community involvement and that of local industries has been virtually non-existent. For the most part, the teacher have relied upon the resources of the school.

Maple School - Direct parental involvement has been minimal. Interested parents have made a commitment for their children to attend Maple School because of the computer program. Some parents of resident students at the school have expressed concern that Magnet students monopolize use of the computer facilities. Plans were underway to expand the computer program to include all students (resident and Magnet) in computer literacy and programming classes in the 1983-84 school year.

Mahogany School - Parents have become more aware of and involved in the use of computers in the school. There are parent volunteers who assist in the classroom as aides. The number of volunteers has increased so much that the school has actually had to turn some away. The teacher cited examples of this new parental involvement. After an article about the use of computers in the gifted classes appeared in the local paper, parents whose children were not enrolled in the "GATE" classes called the school and asked and/or insisted that their children have access to computers as well. The other example centers around the fact that the parents of the children now enrolled in the computer literacy classes are pressing the high schools to further develop their computer programs. They are worried that the skills their children have learned in middle school will go to waste if the high schools do not support and expand upon the knowledge the kids currently have about computers. There is great concern that the students be prepared for the technology that will exist by the time they are adults in the "working world." The parents feel the schools must keep pace with this technology.

Hickory School - Parents are quite positive towards their children learning to use computers. Parents are encouraged to visit the computer center and according to the teacher, "like what they see." The principal noted that the community agrees with the emphasis on job related computer

skills. The business community has also been supportive. One bank has already "adopted" the Business Department at the school. They have made strong recommendations for the goals and objectives of the computer literacy program. Outside support is also provided from the University. UCSD will support a telecommunications program starting next year.

Hemlock School - There was considerable parental involvement in the development of the computer literacy program at the school and in the decisions concerning computer use. Parents recommended the model to be bought and also influenced the type program that was implemented. Parental involvement continues through the School Site Council and the PTA. During the observation period, no parent was present in the class although in general parents did volunteer for other activities at the school.

3. Computer Lessons and Preparation

Eucalyptus School - The teacher spent time becoming very familiar with the piece of software or hardware before he presented it. The time spent using and practicing with the material varied from days to weeks or even months when it was complicated. Once the familiarity was gained, he selected an appropriate application and organized as a lesson topic. Each lesson was designed to last about 20 minutes and included a demonstration of an exercise that each student was expected to perform over the next day or so. Preparation for this phase was only a couple of days at the most. When lesson time actually arrived, the teacher had the students gather around him at the computer in the back of the room, and gave the lesson. Questions were encouraged, and answered to the entire group. When the students began taking their turns at the computer to complete the assigned exercise, the teacher checked on their progress by asking for a demonstration of what they learned, or by looking at a printed copy of their work.

During one class meeting, the teacher invited the observer to give a short talk on Pascal to the class, and then give two selected students a Pascal lesson. The class seemed attentive as a little Pascal program was demonstrated, asking a few questions. It seemed especially effective to relate Pascal commands to the corresponding components of BASIC and Logo with which they were already familiar. The teacher helped out by prompting some of the students with questions comparing the languages. The private 20 minute lesson was given to two students while the rest of the class went on with their normal activities. The observer guided the students through a graphics program which they enjoyed writing and seeing run. It seems that these children were chosen especially for their programming ability as they did remarkably well for fourth graders, catching on quickly to the Pascal concepts.

Ebony School - The teacher designed a single curriculum for all the levels Kindergarten through grade six. He advanced at different rates for the different classes. More lesson preparation was required for the sixth grade and Kindergarten classes. The other classes fit somewhere in between. The teacher took the five minutes between the classes to look over what the class did the week before and to decide whether he would have the students continue on last weeks work or introduce them to a new topic by demonstration. A student aide was primarily responsible for the transition between the classes and helped change the program on the

computers.

The teacher was constantly working to discover new computer uses to share with his students. He had the school buy a new lightpen device and graphic program (Gibson Lightpen Graphics System) which he hopes to integrate into his curriculum. He was also interested in word processing and networking between schools.

Maple School - The teacher indicated that the goal in this class was to give students a good, solid background with computers before reaching high school and college. Students in the seventh and eighth grades spent every other week working on the computer alternating with math and science. The ninth grade students concentrated specifically on BASIC. The teacher prepared about fifteen lessons a week. Some lessons are prepared two weeks in advance, and others the night before. Sometimes she used the previous year's lessons. She usually took about thirty minutes to prepare the exercises for the seventh and eighth grades. The ninth grade lessons for Basic were already planned. Altogether, her lessons required about ten hours of outside planning a week.

The lessons for the seventh and eighth grade classes were introduced with worksheets such as: "How to Use the Computer" or "Programming." The lessons were often introduced or reviewed with an overhead projector. The students worked for about ten minutes on the worksheets. Next, they wrote a program in class with the help of examples, then spent 20-25 minutes on the computer itself. A typical computer lesson for the seventh and eighth grade included twenty minutes of practice with Random Numbers or Graphics. The ninth grade students took lecture notes and spent 30-35 minutes on the computer.

Successful computer sessions often generated excitement among the students. They were able to help each other get their programs to work. Students usually had a lot of questions; but it was often the more advanced ones who asked most of the questions, many of which were currently "over their heads". By moving around in the class the teacher was able to make sure the students were working on their assignments. Students were also given written vocabulary tests in class. Sometimes the teacher used a "privileged account" on the computer to gain access to student work to see whether students were playing arcade games instead of doing their class assignments. Disruptions in class occurred when everyone wanted to work on the computers at the same time since there were not enough machines for every student. Also, once the students got access, they were hesitant to give it up. Sometimes the enthusiasm of the students made the noise level of the room quite high.

Mahogany School - The teacher had written the curriculum guide and student workbook for the computer literacy class. Most weeks the teacher spent 1-2 hours "lining up what to do" in the class. Much of the planning time was spent modifying the student workbook to meet the specific needs of the students, (e.g., explaining a concept that was particularly hard for one group, or reorganizing an explanation of a concept that didn't seem to be clear to the students during the last term). The teacher said he felt he taught the class better as the year goes on because he was responsible for teaching the same class to a different group each quarter.

He emphasized "learning by doing" when teaching computer literacy. The children spent considerable time at the computers rather than hearing a lecture about how to use them. He estimated that each student spent about 25-30 minutes per day on the computer. He generally used the computer itself to introduce students to a new concept by having them work through their notebooks at the computer and later reinforce what they have learned through large group discussion. He spent most of the class period wandering about the room, responding to questions and generally observing, praising and helping the students. Because the children collaborated on their work during the hands-on time, the noise level was louder than at other times. The teacher encouraged this interaction because often the students would be able to figure out a solution to a problem together that they wouldn't be able to do on their own. Because students worked at their own pace, not everyone was working on the same assignment at the same time. This allowed the instructor more flexibility in that he did not have to tailor the lessons for the average ability of the whole group. The teacher aides in the class also helped in this respect.

The learning activities in the computer literacy class were organized into 4 basic components: 1) large group lecture/discussion, 2) small group computer use time, 3) student reports, and 4) testing/evaluation. The large group activities took place with the students seated at the long tables in the center of the room. The teacher stood during this time, walking around the room or standing at the blackboard. The teacher, rather than giving a formal talk, usually asked questions to the students to draw out the main points of the lesson. His questions usually took the form of, "what happened when you did X?" He often referred to an exercise in the workbook. A typical exchange between teacher and students follows:

TEACHER: "What is the term for $D = D + 1$? (pause) 'member on page 23?"

A STUDENT: "A counter."

TEACHER: "What's it counting? (pause)"

A STUDENT: "Numbers."

TEACHER: "Very, very good. Next page. This was the hardest one, if you can do it right, you'll do well on the test. Who did it without using "LET?" Who did it using "LET?" (had two students come to the board and show how they did the problem).

Large group discussion took place 2 to 3 times per week for 20 to 30 minutes. Once at the computers, the children, for the most part, worked in pairs. They chose their own partners. The students generally took turns entering and reading the exercises from the worksheet so that one student read one exercise, while the other entered it into the computer. After they ran the program they switched jobs. One group had to be timed by the teacher one day so that each partner would get equal time on the computer. He timed them at ten minute intervals and then had them switch. A few other groups divided the keyboard in half so that one person entered on the right half and the other entered on the left half.

During hands-on computer time, questions were handled in a number of ways. The first situation I observed occurred with a pair of girls. Each time they encountered a problem, for example, the screen printed, "Syntax error," they immediately raised their hands and waited for the teacher or aide to come over and help them. Later, I observed other kids first trying to solve problems themselves. They would, for example, list their program to compare it with their worksheet to see if they could figure out what went wrong. Often, if they weren't sure what was wrong, they would try to "troubleshoot" by entering something they "thought" might work. In one situation, two boys ran into problems, when they gave the computer the command to "RUN." It did nothing. They tried first to list their program to see if they could figure out what was wrong, and when they couldn't see what was wrong, they asked the group of boys next to them if they could tell what was wrong. These boys offered suggestions, none of which the other boys accepted. Once the volume rose, the teacher came over and helped them out.

The transition from computer time back to the central area did not occur as quickly as the transition in the other direction. About 5 minutes before the end of the class period, if they had not already returned to the central area of the classroom, the teacher had the students stop work at the computers and return to the tables for dismissal. He announced that it was time to return to the tables and then 2 to 3 minutes later, he had to literally turn off the power supply to the computers to get the students to stop working. There was usually some objection, "Can't we just finish this one," "Oh come on.." but to no avail. They then gradually returned to their desks.

Another part of the class time was devoted to student's reports. The teacher wanted to present the kids with a broad historical as well as practical base and so he had the kids give oral reports on some aspects of computers. They chose what they wanted to do--report on an article, or even demonstrate a program they had written. Since "kids listen to kids" he has the students present the information rather than doing it himself. Each child was required to give a report at some time during the quarter. For example the reports included the history of the abacus and a demonstration on how to use it or robots development from remote control units to programmable units. One student showed the class a program he wrote of a banking system which compiled interest and deposits by the month and gave totals.

The final category of activity which occurred in the classroom was testing and evaluation. This occurred much as it did in other classrooms, where tests were in written form and did not take place on the computer. The students also turned in their computer workbooks at the end of the term. The teacher felt he had more flexibility than some teachers in evaluating his students so if a student did not complete all of his assignments, but wrote a very good program he could still get a good grade.

Hickory School - This teacher has 5 computer classes per day. The amount of time needed to plan an assignment and its accompanying lessons varied according to the degree of difficulty in the subject matter. During one semester, the teacher planned 7 to 10 assignments per week requiring 2-10 hours of preparation time. One additional hour per week was necessary

to prepare the physical environment for an assignment (arranging files, moving relevant material).

The teacher presented new concepts and programming statements using an overhead projector and chalkboard. Then students moved from desks to the computers. Students were given assignments which required the use of new concepts and statements. Evaluation of the assignment followed, which included an output and listing of the program, a program RUN for the teacher and oral evaluation between teacher and student. The teacher supervised all the class activities by circulating among all students, both in the computer area and in the desk area. A computer lesson was considered successful when the teacher felt there was significant progress with concepts and when students displayed a feeling of accomplishment.

Hemlock School - The computing curriculum addressed broadly conceived computer literacy objectives. Instruction centered around specific computer applications and the types of problems they are particularly good at solving. The students worked on projects using a range of software tools such as spreadsheet analysis, graphics design, word processing, data base management, simulations like Flight Simulator and a brief introduction into video games. The teacher began each class period with a brief lecture about the current assignment. The students then moved to the computers to work in small groups on a specific task using a software tool. For example, using Visifile, each group made up five fictitious people with addresses and blood types. They were then sorted according to various categories and lists were printed.

4. Availability and Access

Eucalyptus School - The computer was located in a lockable 'Apple-Cart' which can be rolled to the main office or to any class that needs or wants it. Requests went through the teacher, who was in charge of the equipment. Before and after school, the computer was available for use by the school's computer club or other motivated students. At times when the computer was needed for administrative uses, it was wheeled to the main office where the secretary could use it. The software, on floppy disks, was available to staff members for use at home, as well as some of the peripherals. Students could borrow software under special approval of the teacher, however this was rarely done since few of the students have compatible computers at home.

Ebony School - All students at Ebony School were required to spend 30-40 minutes per week at the computer as part of their curriculum. The computers were available before school, during lunch and after school on a sign-up or drop-in basis. The students who took advantage of this opportunity were usually fifth or sixth grade boys. Time was split between working on class projects or outside recreational material. The teacher no longer allowed arcade games in class. There were usually 10-15 students in the class during these times. Computers were available for teachers to use by arrangement. Teachers were encouraged to take the computers into their classrooms or take them home over the weekend. Rarely more than one or two teachers a month took advantage of this opportunity. However, teachers' interest was increasing since they will be responsible for instruction using computers next year. The computer room was used about one afternoon a week for adult classes which were

organized by the school district. The students are primarily district teachers.

Maple School - The computers at this site were available for the students' use during and after school. On the average, a seventh or eighth grade student spent 20-25 minutes out of 55 minutes of classroom time working at the computer. Five groups of seventh and eighth graders shared the ten computers during the week. The ninth graders are in a different room and shared one terminal between two students. The Magnet students had the most access to the equipment. Plans were underway for the resident students to get more time and training on the machines during the 1983-84 school year. The Magnet students could gain access to machines only with teacher permission.

Mahogany School - All staff members had access to the computers by checking them out through the teacher. Teachers could also check out the Apples during the day to use in their classrooms, and overnight and on weekends so as to get more familiar with them. The children also had considerable access to the computers. Although they were not permitted to check the computers out and take them home, there was time scheduled before and after school in which they could use the machines. The teacher arrived an hour before the school day began to let children in to use the computers. He stayed after school on Mondays and Thursdays as well for the same purpose.

The children were allowed a fair amount of flexibility in what they could do on the computers, although the teacher discourages them from bringing in games unless they write them themselves. He had specifically set aside Mondays for the sixth graders to come in and work on the computers. He said that they are sometimes intimidated by the older, bigger kids and wants to give them their own time to explore. Lunch time access to the computers is limited to the "peer" t.a.'s as a reward. The community also had access to the computers through an adult education class taught on Monday and Wednesday nights by the teacher.

Hickory School - During class time, students enrolled in the computer literacy class had priority in using the computers. Since there were more students than computers, students could access a computer either on an individual basis or in pairs. The teacher stated he felt the ideal ratio would be one computer for every two students. There was no fixed schedule distributing time and computers among students, therefore accessing the computers involved working alone, working in pairs, or taking turns. The overseer of access to the computers was the teacher. In the class under observation, students spent 60-70 percent of their class time at a computer. Outside of class time, all people (students, teachers, staff) had access to computers. Access was allocated on an informal first-come first-serve basis, restricted only by computer availability and supervisor's time schedule. Students were encouraged to bring their own software from home and use it on class computers. However, no "pirating" of software was allowed. Students could play arcade-type games on the computers outside of class only. Computers could not be taken home.

Hemlock School - The computers were available to everyone in the school during lunchtime and class periods when there was no scheduled class in the computer room. The teacher kept track of the usage of computers and

software. The computer literacy classes were open to all students in the school. There was no formal screening process. The computer literacy courses are filled mostly by seniors due to priority in registration.

5. Physical Arrangement

Eucalyptus School - The computer and associated equipment were housed in a rolling 'Apple-Cart' which could be moved to any location in the school that has an outlet. Typically, though, the computer stayed in one classroom which is situated in the middle of the school. The computer usually resided in the back of the classroom where it was available for students to work in pairs during class time. Sometimes it was pulled up to the front of the room when an important task, such as tallying CUE conference survey cards, was going on. The arrangement of the room was such that computer was visible to all the students when a new topic was being introduced. Work by children in the computer club and other interested students also took place before and after school in the same classroom. For special assemblies, the computer could be moved into the auditorium for the whole school to observe.

Ebony School - This school had classrooms that were semi-partitioned areas within one large room. The computer center was one of the few rooms that was completely walled off. It was located in the corner of the building, had no windows, one door to the outside and one door to the inside of the building. The classroom itself was richly decorated with pictures, posters, and computer information on all the walls. There were several counters, cupboards and a book shelf lining the walls. The tables for the computers were arranged in a 'U' in the center of the room. The computers themselves alternate directions to allow maximum space, one facing inwards and the adjacent one turned toward towards the walls. The teacher's central computer was at the end of a table protruding from the center of the 'U'. The Apple II+ computers were interconnected using hard-disk supported local network.

Maple School - The ten computers in the seventh and eighth grade classrooms of this Math, Science and Computer Magnet were in what was formerly a Home Economics lab. A long lab counter ran around three walls of the room with six extensions jutting out at right angles to it. The machines sat on these extensions. Because of the equipment lay-out, students did not all face the same direction. Some sat back to back between the extensions. Those not using the computers sat at tables in the center of the room doing homework. In the ninth grade, the computers sat on a long counter against a wall with windows and on two tables against another wall. The grade 10-12 classrooms have DEC terminals. Most of the microcomputers are located in grade 7-9 classrooms and in the library.

Mahogany School - The classroom itself was located just off the central quad of the school, directly across from the office. The door of the room had special bars installed to deter break-ins, thus setting it apart from the usually easy access of the other classrooms on campus. The computers were located on tables around the walls of the classroom. There were generally two students per computer, unless one of the pairs was split up for disciplinary reasons. During the lecture time, the students sat at the long tables in the center of the room. The room might be described as sparsely decorated. There were posters describing

the computers in the classroom. The room held the 28 students comfortably, with plenty of space to move about between the tables and computers. There are 14 computers in the classroom-12 Commodore VIC 20s and 2 Apple II+s. The VIC 20s were permanently arranged along three of the walls the two Apples were on moveable carts so that they could be used by other teachers in their classrooms.

Hickory School - The physical setting of the Computer Literacy I class was in a larger than average room (approximately 15 meters in length and 12 meters in width). The room was divided into two distinct areas: the computer area and the desk area. As one entered the classroom, the right side houses the computers and the left side the desks. The computer area formed a hollow square, with 17 IRS 80 Model III computers and 1 printer facing in. Along the back side of the room, between the computer area and the desk area, there were 3 more computers and 2 additional printers. The computer area was open and easily accessible. There was no special user schedule posted. The desk area was located in the other half of the room. There were four rows of tables for students with the teacher's desk and a storage area for computer software in front. At the back of the classroom there was a reference area which contained 2 computer magazines, computer paper in boxes and 6 computer user's manuals.

As one enters the classroom, the walls of the room were filled with various computer-related information: on the right wall, there was a chalkboard and bulletin board with cartoons dealing with computer use; on the left wall, there was a bulletin board which had large posters titled "Career Ladders in Computers"; on the front wall, another chalkboard and a bulletin board which had the "Computer Literacy I Grading Policy." The only structural changes made to the classroom to accommodate the computers was the addition of electrical wiring and sockets.

Hemlock School - The computer center was located in one wing of the school, in a large hall that also housed the Language classrooms. There were cubicles along the wall of the classroom for individual work. Long tables were placed in the center of the room for the computers. In front of each computer were two or three chairs. On the walls there were various computer related posters and some graphics created on the computers by the students. While there was a schedule sign-up sheet on the wall, it was not currently being used. Approximately 30 people could fit comfortably in this classroom.

6. Integration into Curriculum

Eucalyptus School - Computer lessons were given two or three times per week and were treated like any other subject taught in the class. A topic was introduced and the students practiced the skill by doing short exercises between the lessons. The students worked in pairs while the rest of the class continued the whole class lesson. One pair notified the next to begin work when they have finished with the computer. The switching went on smoothly throughout the day with little or no interruption of the rest of class. Most of the subject matter was chosen to fit into the topics selected by the teacher. Software packages were included because they were especially well done (eg., Odell Lake). The standard topics covered were data base management, communications,

graphics, programming word processing, and some computer aided instruction, with the computer applications filling about 30% of the computer curriculum. In relation to the other class work, time spent on computer topics amounted to 2-3 hours a week with an additional 1-2 1/2 hours per week of hands-on use for each student.

Ebony School - Computers at this site were not integrated directly into the curriculum. Primarily Logo was used as a means to promote general thinking and problem solving skills. The aim was to avoid limiting computers to a particular use but to provide the students with a tool that will help them in a variety of problem solving situations.

Maple School - Computers at this site were currently accessible mostly to students in the Magnet program. The activities in the classes are carried out along the continuum: motivation-introduction-instruction-examples-practice-evaluation. The continuum began by using exciting programs to get the younger students interested and motivated. Math, random numbers, and graphics were introduced to the students as they progressed. The teacher did not present many software examples since she has not found them useful. Evaluation was carried out by written tests and by checking the programs the students are doing on the computer. The distribution of time committed to each component was approximately: 50% motivation, 25% introduction, 2% instruction, 20% practice, 2% examples, and 1% evaluation.

Mahogany School - Computer literacy was a required class for all the grade six students at this school. Due to budgetary constraints, during the 1983-84 school year, the current teacher may be required to teach a regular class schedule and therefore will not be available to teach computer literacy to all the grade six children. The other 6th grade teachers plan to add computer literacy instruction to their own teaching responsibilities. Each was spending the current year "learning by doing" along with their students in the computer classroom.

Because two of the computers were on wheels, some teachers have also been using them in other subject areas of the curriculum. They were checked out for use in math classes and in the special education class for computer literacy. Other instructors had used the computers for spelling and math instruction, while one of the specialists who works with children with discipline problems uses the computers and computer games as a reward system in his class.

Hickory School - The curriculum was specifically designed to teach students about computers and how to use them in business related situations. Computers were also integrated into the English department indirectly by the coordination between teachers to improve writing skills of the students. Also, the Journalism class and Associated Student Body expressed the desire to use the computers as word processors to ease their work load.

Hamlock School - The computer literacy classes at this school were electives available to all the students. The focus of the class was the demystification of computers by exploring a range of computer supported tools and their applications. The teacher described his primary goal in the following manner:

"The students are now comfortable with the computers, without the awe and intimidation felt by many. They are aware of computers' capabilities, and may now be able to use them to help them solve problems. We are stressing the viewpoint of future computer users, not just programmers".

The implementation of this policy consists of exposing students to software tools like: graphics and music composers, word-processors, data-base managers and spreadsheets.

7. Hardware Problems

Eucalyptus School - The teacher wished he had more computers, ideally one for every two students. The hardware itself worked fine, although they did have some difficulty with their card reader overheating at times. A complaint was made about the security of the equipment, since the classrooms at the school can be broken into without great difficulty.

Ebony School - One technical complaint was that the hard-disk network system did not support UCSD Pascal system software. Pascal software could not be down-loaded from the hard-disk to the Apples. Also some of the donated equipment was outdated or required extensive repair.

Maple School - The school had 32 DEC PDP1160 terminals, 30 Apples, 8 Pets, and 2 Telemath machines. There does not seem to be a major problem getting necessary hardware. The staff had technical problems adding additional memory to the DEC mainframe computer in order to accommodate more students. The school board was very supportive with requests for additional hardware and the school plans to get more computers next year to expand the computer literacy program to the resident students.

Mahogany School - The teacher complained that the networking system did not work as promised. The children could not save their work by loading it to a remote floppy disk. Once they turned the computer off, their work was lost. In addition, they were unable to use the software written for the VIC20 computer system since it is designed for individual disk drives or cassette recorders.

Hickory School - All the computers at this school were Radio Shack TRS-80 Model IIIs. There were three printers for the twenty computers in use in the classroom. The main hardware problem was the shortage of printers for the heavy word processing use. Because only one computer could be connected to a printer at one time, as many as three computers were tied up printing when they were needed for class assignments. The funding priority for next year is the purchase of more printers. There is a TRS 80 local network system in the classroom but it has never functioned properly. The teacher was eager to find a way to interconnect several computers with one printer to ease the printing bottleneck when term papers and articles are due. Within the next five or six years, the teacher envisions another room outfitted with computers, perhaps IBMs or other business oriented computers.

Henlock School - There have been no real hardware problems at this site. However there has been a problem with locating adequate software at a reasonable price. Currently there is not a lot of student-oriented

software written for the IBM Personal Computer. This problem is gradually being solved as new software comes on the market and the availability of an interpreter which enables the IBM PC to run Apple programs.

8. Software

Eucalyptus School - The class used the Applewriter text editor extensively for word processing applications such as term papers and class reports. The ASCII Express communications package was used for getting access to the Source timeshare system and also for communicating with the handicapped students at the Civic Center via a modem and phone link. Record keeping and other database activities were done with the PFS database software. This included the school database which contains about 20 items of information on each student at the school. They also have the complete MECC series which they use for CAI applications.

For programming, the class used Applesoft BASIC, and various versions of Logo. Art and graphics were developed using Alphaplot which allows the students to create, edit and save multi-colored drawings and geometric creations. Other public domain software was available and was used occasionally. Games were not permitted during class time, but could be played before or after school if the machine was not being used.

Ebony School - All the software used at this site was purchased with magnet funds. The teacher chose the programs based upon reviews in software magazines. Logo was the basic tool for instruction and was used to run a variety of programs written by the teacher. Other software was used to a much less extent including Meteor Math, Bankstreet Writer, The Menu, Lemonade, Odell Lake and Oregon Trail. The teacher felt all that is needed for a successful curriculum is Logo and a good word processing program. He would like to have access to the interactive writing program used at UCSD but it does not currently run on his local network system since it is written in UCSD Pascal.

Maple School - The software at this school consisted primarily of drill and practice activities and the teacher generally does not use them. According to the teacher, most of the software available on the commercial market is of poor quality. There have been problems in the past with students swapping and buying discs to get out of writing their own programs. However next year they plan to use Logo.

Mahogany School - The observed teacher had the responsibility for the evaluation and selection of software for the school. He used a system published in the October 1982 issue of "Electronic Learning" as criteria for choosing software. He did not use software for computer literacy. He recommended a few products which he considers to be quite good: "Oregon Trails," "Division Derby," and the Millikan Math Series.

Hickory School - This class used Radio Shack Superscript Set for word processing and Radio Shack Three Plus for data base management. Students also wrote their own programs in BASIC. This software was not personally selected by the teacher but rather was ordered before she came to the school. However, she was familiar with the software. Selecting software for the school begins with a recommendation by a teacher, based on software reviews or professional consultation between

teachers. Recommendations are then given to the department head. The teacher would like to see the addition of three software packages: a data base package using two disk drives, NEWDOS 80 and NEWDOS PLUS. The staff also plans to introduce Pascal in the near future.

Hemlock School - All of the software in use in this program was selected to enhance students' understanding of the power of computers and provide hands-on application experience. Some examples of the software in use are Visicalc, Flight Simulator, Visifile, and Rat-Bas (a programming language similar to Pascal in structure, but that compiles to Basic for editing). The teacher is also looking for a good, reasonably priced Pascal system for the IBM, and for several new software packages including TK!Solver (an electronic spreadsheet program to aid problem solving), and Abstat (a statistics package).

9. Support

Eucalyptus School - The teacher relied mostly on other interested educators and personal friends for handling problems. Extensive technical assistance was also available from TECC center. The teacher would prefer to have a few well trained aides on hand to assist with problems and a software writing staff available to do software revisions. Currently, revisions are done by himself, or by interested friends. In the future, if the Adopt-a-School program works out, some computer companies may be able to provide the technical and financial assistance needed by the school. Currently, the only money available is from the School Improvement Plan which paid for their equipment.

Ebony School - The success of this program seems to be the result of a great deal of work by the teacher and the principal. There has been no industry or community aid. The district has provided transportation for minority students transferring to this school to participate in the Computer Magnet program. There was concern that sufficient funds would not be available to carry on the program for the 1983-84 school year but the program got last minute funding to continue. For future years, the prospects of continuing look bleak.

Maple School - This site received little support outside the school district and the Teacher Education and Computer Center. Occasionally Applecore sponsored computer contests. The teacher thought it would be helpful to obtain support for the development of software useful in other subject areas such as history, science, language and programming, but knows of no other sources for support. She found the best resources are among the faculty at the school.

Mahogany School - The teacher's role at this site encompassed many different aspects of the use of computers at the school. He taught computer literacy and programming electives in the middle school and courses for adult school. He is responsible for software evaluation, monitoring and scheduling the computers and also develops curriculum for both the computer literacy and elective programs. The teacher felt that he was not currently getting adequate support, that he had too much responsibility and too little time, and that he, like most public school teachers, is underpaid and overworked. He would like to see the school district hire a person to oversee the evaluation and acquisition of software. That would lighten his load so that he could have more time

to keep up with the state of the art. He was also concerned that even though he might not be the "computer resource person" next year, he would still be the one teachers will run to for assistance, therefore he will have the same responsibilities, unofficially.

Hickory School - Technical support and advice about computers was received from various sources including 1) TECC center staff, 2) school district (this support is labelled "minimal" by teacher), 3) Radio Shack Inc., 4) CUE (a professional organization for Computer Using Educators). The teacher stated that 80% of all support comes from personal ties within the CUE organization. Whenever a problem arose with software or curriculum, she frequently would contact colleagues in CUE. The type of support needed to continue the success of the program is better software, more printers, and additional financial support from the school district.

Hemlock School - Because of his level of expertise, this teacher often finds that he was called upon by other teachers to support their computer use activities. The teacher tended to rely on magazines, books, dealers, and various acquaintances for up-to-date information on the machines. So far there had been no major problems with the computers, hardware or software, so true technical support had not been necessary. The teacher read software reviews, and would like to be able to preview programs to know more about them before recommending that the school buy them. Fortunately, the school district was considering forming a central clearing house for software. Community support has been good, although not overwhelming. A UCSD professor assisted in the beginning with the selection of and setting up the program.

10. General Impact

Eucalyptus School - Many of the teachers at the school who were originally frightened of computers now welcome them into the school. A few teachers had actually bought Apples of their own, and two teachers used the AppleCart in their own classrooms on occasion. A few teachers still refused to accept the computer. About ninety-five percent of the students in the school had some hands on experience with a computer. Parents were eager to get their children enrolled in the computer program as evidenced by the excess of parent request forms for participating in the "school within a school" computer program. The school has purchased three additional Apples for the 1983-84 school year.

Ebony School - Teachers at this school for the most part had not been directly effected by the introduction of the computers. They had left most of the responsibility for computer instruction with the teacher. Funding for the program did not reduce materials available for other instructional purposes. The computer teacher was shifted from a regular teaching position to the Computer room. One additional aide had to be hired. Computer literacy is a new subject area for students but its addition to the curriculum did not seemed to detract from studies in other areas. Its long range effects on motivation for school and learning other subjects has yet to be documented.

Maple School - The greatest impact that computers have had on faculty was that some teachers in the school have become more interested in them and

their classroom applications. Other teachers were not interested in the program at all because they felt that computers were de-personalizing. The teacher feels that access to computers has had a positive effect on general student motivation for school and learning. Students worked harder in all their classes and were much more motivated to learn. The main problems were lack of access time and equipment.

Mahogany School - The introduction of computers has had a very positive impact on both the students and teachers. Both groups are more aware of computers and what they can do. A growing number of them are becoming more involved with using computers.

Hickory School - The general response by other teachers to computers at this school was "extremely positive," according to the teacher. There was a high level of coordination between departments for meaningful computer-related assignments and several teachers were enrolled in computer courses after school. Other departments expressed interest in becoming involved with computers soon. The response of the students to computers was also very positive as demonstrated by the popularity of the class. The school seemed to have generally accepted the use of computers; even its yearbook has a computer theme.

Hemlock School - The computer center had a major impact on the school at large. Not only were more students familiar and comfortable with computers, but they seemed to be loosing interest in some of the other technical electives such as auto-mechanics and wood-working. The computer program was growing at a fast rate. Plans were underway to incorporate more computers into other subject areas like Mathematics, Journalism, Foreign Languages, Social Studies and Business. Teachers were already gaining the necessary expertise for integrating computers into their classes.

11. Teachers' Views of the Near Future

Eucalyptus School - For the 1983-84 school year, the teacher in this school is going to get three more Apples, and more students. The teacher plans to purchase additional graphics utilities, some of which have already been ordered, and the PFS school record keeping system. He also plans to expand his classes' involvement in communications. An attempt will be made to use the graphics capability of the Apples to support the art curriculum as part of the Fine Arts Magnet program also housed at the school. He hopes to eventually have the students writing programs for specific applications rather than just for practice. He intends to learn more about computers and programming and will continue to teach in the field.

Ebony School - The 1983-84 school year was still very much in the planning stages at the end of our observations. It now appears that the program will continue for one more year. At that time, it seems likely that individual teachers will become responsible for teaching their students in the computer lab and no computer specialist will be available. Teachers will be expected to integrate the use of computers into their curriculum. The current computer teacher believes that a few will be able to do so creatively and successfully while the majority will resent the intrusion and the time it takes to learn how to use the computers. These teachers will most likely use the computers for drill and test and

other self contained programs.

Maple School - The teacher indicated that in her opinion, there are a few possible detrimental effects computers may have on learning and instruction. One is that students will write fewer essays. Students will spend less time on writing altogether and more time on learning math and science skills. The teacher was also concerned about possible negative effects of students getting along better with their machines than people, especially at the critical age when they should be learning how to relate to other human beings. The teacher felt that instruction was likely to evolve over the next few years in that less time will be needed for drills in basic math. Whereas students previously spent about four years learning how to divide and spell, computers will be able to do this for them. She also felt there will be a need to change the overall curriculum in schools so that students can prepare for more than a single vocation. On the whole computers should continue to help the students in their learning process and enhance their enjoyment of life.

Mahogany School - The teacher has both hopes and fears about the future with regard to classroom computer use. He feels that "the whole picture will change", that the school will have a better outlook in that the more positive experiences teachers and students have with computers, the better the instruction will become. He expects that his school will be getting more computers in the future so that they will eventually be able to lower their student/computer ratio to 2/1. Next year he plans to have the GATE students learn Pascal.

The teacher also expressed fears that computers may become another form of escapism in the future. Though they can be an aid in improving communication, they can also isolate people from one another. Computers could also become toys for the rich, creating just another form of illiteracy among the poor. Finally, he felt that teaching should and will be radically changed by the computer. Currently schools are training students for jobs that will not exist by the time they are adults. The schools have to keep up with the technology in the "real world."

Hickory School - The teacher at this site will continue to teach computer literacy next year. The original program was designed to be implemented over a two year period so the computer literacy program will be the same for the 1983-84 school year. After that year, the goals will change according to the needs of the school and the expertise of the teacher. All six computer literacy classes are fully enrolled for next year. The emphasis will remain on business-oriented computer processes. The teacher would like to see the implementation of Pascal programming, and perhaps the purchase of IBM PCs, and the expansion of the computer curriculum to encompass two years of training for the students. The teacher is learning Pascal this summer and will be polishing her skills at LOGO.

Hemlock School - A card reader has recently been purchased for use during the 1983-84 school year to be used for scoring tests. Plans for next year also call for a program for students to develop new levels of health and well-being by monitoring and evaluating student health on the basis of age, sex, family history, exercise, health status, etc. Computer

generated reports will go home with the students periodically during their four years at the school. This program should be implemented by the second semester. Additional computers are being used in English, language and mathematics classes.

APPENDIX II

Computers in Schools: Stratifier or Equalizer?

University of California, San Diego

The Computer Use Study Group University of California, San Diego Participants in Comm 109/TEP 162 contributing to this paper are: Marcia Boruta, Carol R. Carpenter, Mary Harvey, Tamara Keyser, Joanne LaBonte, Hugh Mehan, and Delia Rodriguez. This paper will appear in The Newsletter of the Laboratory of Comparative Human Cognition, Vol 5, No. 3, July 1983.

Computers in Schools: Stratifier or Equalizer?

Computers are being promoted as the educational tool of the eighties. Almost daily, we are being informed of the dangers of a computer illiterate society. With almost blind faith, schools are taking on the responsibility of supplying computer education. As history has shown us, innovations in social systems have unforeseen consequences for those systems (Sarason, 1982). These effects can be both positive and negative. But, in most cases, and most importantly, they have been unanticipated. As schools acquire and use microcomputers for educational purposes, the following are some of the questions that concern us:

- (1) will students from different strata of society obtain equal access to computers?
- (2) will students from different strata of society be taught similar or different uses of computers?
- (3) will computers enter schools briefly, and then, like previous forms of educational technology, be stored in the closet because teachers fail to find ways to use them to accomplish their educational goals?

In short, we are interested in trying to determine whether computers will be tools which facilitate equality among different social groups or whether they will be tools which further stratify groups within society.

We know something about the numbers of computers that are in U.S. schools. For example, a national study of educational technology in 1983 reported that 53% of all schools in the U.S. had at least one computer as of January 1983 (Center for the Organization of Schools, 1983). The pace at which computers are being acquired by schools is so rapid that a 1974 survey of educational technology did not even have an entry for microcomputers in its survey instrument (Kincaid et al, 1974). The State of California conducted its own survey in 1982; that report indicated that 29% of the schools in California have at least one computer or terminal. Miller (1983) reports that 83% of 402 schools in San Diego and Imperial Counties have at least one microcomputer.

We know less about the distribution and use of computers in schools than we know about the numbers of computers in schools. With few exceptions, e.g., Sheingold (1981), studies of computers in schools do not report whether students have equal or differential access to computers. Sheingold (1981) found that computers were being used most often in resource rooms and hallways, and seldom in classrooms. She speculates that the placement of computers in hallways and resource rooms may have been the result of a commitment to achieve equity because all students could pass through these computer centers. As soon as computers began moving out of hallways and into math and business classes, differential access became apparent. Only those students who elected or were selected for these programs received instruction on computers. She also reported that many more boys than girls use computers at all grade levels, but she did not indicate any ethnic group or social

class differences in computer use.

The Approach of This Study

In order to get some sense of the relationship between the numbers of computers in schools and students' access to computers, we arranged to observe computers being used for educational purposes in 21 schools in five school districts in two Southern California counties in January, February, and March of 1983. The schools ranged in student population and computers available for educational purposes. The relevant information about the schools and their computers is summarized in Table 1.

Table 1

School or District	Number of Students	Number of Schools	Number of Computers
Sierra	700	2 elementary	22
Piquin	4781	8 elementary	26
Cayenne	3692	9 elementary & secondary	183
Chipotle	625	1 secondary	57
Jalapeno	674	1 elementary	5
Total	10,472	21	293

Students were the primary users of computers. In all the schools we observed, students had priority over teachers' record keeping and administrative uses of computers. This observation contrasts sharply with an NSF sponsored survey of secondary schools conducted in 1970, which showed that computers were used for instructional purposes in only 13% of secondary schools (Darby et al, 1970).

We did not select these schools according to a formal sampling procedure; we capitalized on personal contacts to facilitate access. Since our schools were not sampled randomly, care must be taken when generalizing from the information that we obtained.

Likewise, we did not randomly sample the people to be interviewed. If there is a formal term to characterize our approach to interviewing, it would be called the "snowball technique." We started with the teacher, resource person, or whomever we could find who knew about computers in the school. When an interview was completed, we asked that person for the name of others involved in computer use, and interviewed them. We continued this procedure until there was no one left to interview.

Our observation schedule was much easier, for, as we will explain below, computer use in most of the schools we studied was centralized in a media or resource center. The centralization of computer activity facilitated our observations. Our observations and interviews were guided by a common set of

orienting questions about the distribution and use of computers in schools. (The guiding questions for observation and interview are available upon request.) We often found that different educators in the same district had inconsistent answers to our questions. For example, one educator might indicate that the rationale for using computers was "to raise test scores," while another might suggest "enrichment" as the reason for investing in computers. Before reconciling these different views, we treated these responses as indicating the novelty of computers in education which create discrepancies in the reasons cited for their use.

Stratifying and Equalizing Effects of Computer Use

In order to get some sense of the stratifying or equalizing effects of computer use in schools, we examined the relationship between the characteristics of schools and the students they educate and the policies and practices of computer use. We found a very strong relationship between (1) the source of funding for computer acquisition, (2) the type of students who are educated using computers, (3) the type of instruction students are exposed to and (4) the rationale for computer use in the five districts that we studied.

The Sponsorship for the Acquisition of Computers and Students' Access to Computers. The acquisition of computers has been sponsored by many agencies. The State of California and the Federal government were the most prevalent source of funds. Money available for the education of "gifted and talented" youngsters (GATE), "economically and culturally disadvantaged" students (Chapter I), school improvement programs (SIP), and the desegregation effort purchased 93% of the computers in these districts. Private funding, most notably donations from PTA groups, accounted for 5% of the computers acquired. PTA groups sold land, sponsored "jogathons," and collected aluminum cans in order to acquire computers. One enterprising teacher had a local computer store "sponsor" her classroom in exchange for the loan of microcomputers.

Interestingly, no "line item" budgetary funds were used by these districts to acquire computers, which contrasts with Sheingold's (1981) findings. The Piquin District systematically used principals' discretionary funds to acquire computers; this was the only district that spent its regular money on computers. However, the Sierra district now has a \$20,000 "line item" in its annual budget for software acquisition and maintenance.

There is a relationship between the source of funds used for computer acquisition and the students who have access to these computers. Chapter I, School Improvement Program, and desegregation funds are used primarily to educate ethnic minority and lower class students on computers, while GATE and private funds are used primarily to educate middle and upper middle class students.

Computer Location and Student Access

There are 3 major arrangements for computer use in the districts that we studied. Computers are either placed in central labs, or they are assigned to special programs such as GATE or Follow Through, or they rotate between special programs and classrooms. We found only one classroom in which a computer was assigned on a regular basis.

The modal location of computers is in math, media, or computer labs. Nine of the 21 schools we surveyed placed their computers in a central facility, and rotated students through the lab. We could not determine whether this arrangement represented a planned curricular choice designed to achieve equity (Sheingold, 1981), was a security measure or a pragmatic response to the fact that there were not enough computers to assign to each classroom.

Instead of having students rotate through a central lab, five of the schools in two of the districts rotate 10 of their computers through classrooms on a regular basis. This "computers on wheels" arrangement gives students exposure to computers on the average of once every two weeks. Students' access to computers is increased in one school, because a teacher has volunteered to run a "computer club" after school for all students who are interested.

Five of the eight schools in the Piquin and Cayenne Districts assign their computers to more than one group of students. Before school starts in the morning, computers are assigned to GATE teachers for use with high achieving students. The GATE students voluntarily come one hour 40 minutes before school to participate in this program. Then later in the day, these computers are placed on carts and go to other classrooms.

In sum, 89% of the computers in these five districts are assigned a single use--in labs or special classrooms, while 9% of the computers are assigned a multiple use--either rotating between classrooms or rotating between GATE classrooms and regular classrooms. The remaining 2% of the computers were still in storage at the time of our study. We find the rotational arrangement interesting for two reasons. One, it shows a creative use of funding; funds originally available for a special group of students are being spread to students in "regular" programs. Two, it indicates that "special" students are being given greater access to this new technology than "average" students.

The location of computers in schools dictates their use and students' access to them. In the Sierra District and Jalapeno School, which have central computer labs, all students kindergarten through sixth grade have access to computers. In the Sierra district all students visit the lab on the average of once every two weeks with their reading groups. One child works at a computer for about 40 minutes at a time, which produces an average of 20 minutes per week of computer use. In the Jalapeno School all students rotate through the computer center once a week at half hour intervals.

The practice of this equal access policy was not as prevalent in the Chipotle School, established as a "magnet" to attract white families to an inner city ethnic neighborhood. The stated policy of the Chipotle School is similar to that in the Sierra and Jalapeno Districts: to give all students equal access to computers for instructional purposes. However, we observed disparities between stated policy and observed practice which point to the potentially stratifying effects of computer use.

The Chipotle school functioned almost as two separate schools. It provided self-paced computer classes for each of its 6 grade levels and supporting activities in math and science. Ethnic minority students from the local neighborhood who were not a part of the magnet program did not have computer education as part of their curriculum. Instead, they participated in

an academic program which stressed basic skills taught in a regimented fashion with workbooks.

Ethnic minority students who came from the local neighborhood only had contact with computers in Math and English Skills Labs. The Skills Labs are centers stressing basic skills that are tutored by a specialist and reviewed on the computer using drill and practice methods. Most of the white students in the magnet had access to the computers for programming or problem solving activities.

We observed a similar practice in the magnet high school of the Cayenne School District. While all students had access to the computer in this school, instruction was stratified by ability groups. Programming courses, for example, were arranged in four levels. All students in the school were given the first, basic year of instruction. Only high achievers (which include all the white ethnic transfers) were given access to higher level and advanced programming. Low achieving students, which include all the local ethnic students, were sorted into vocationally based instruction after the first year.

Likewise, in the Piquin district which has a "multiple use" policy, there are differences in student access to the computers. In the schools where computers are assigned exclusively to GATE classrooms, each GATE student averages 60-80 minutes per week on the computer, and other students have no access to the computers at all. In the schools that rotate computers between GATE classrooms and other classrooms, each GATE student has 40 minutes per week on the computer, and other students have 20 minutes per week on the computer. But, not all students in regular education programs gain access to the computer under this arrangement. While all teachers who ask for computers can get them, not all teachers do ask. Those teachers who participate in rotating computer activities have computers in their classrooms on the average of two weeks a year. Thus, where computers are being used in regular (i.e., not GATE, Special Education, or Chapter I) classrooms, it is because teachers are highly motivated or highly knowledgeable. Hence, the policy of placing computers on wheels seems to increase the number of students who have access to computers. However, the amount of time available to any one student is less under this arrangement.

We also found that boys and girls had differential access to computers, especially in secondary schools. In elementary schools with central lab facilities, boys and girls had equal access. However, observation of voluntary time on computers (e. g., at lunch and recess) revealed more boys than girls using computers in their spare time. The stratification of boys and girls on computers coincides with the curricular divisions of boys and girls in math and science subjects.

Instructional Applications of Computers

Computers are being used in conjunction with a wide range of subjects in elementary and secondary schools, including math, English (notably vocabulary, spelling and grammar), science and music. Students are also being taught how to program computers and how to use the computer to practice problem solving and test hypotheses.

The most prevalent instructional applications of computers in the 21 schools were basic skills instruction and computer literacy, priorities which

are consistent with CSOS' (1983) national survey of computer use. In basic skills instruction, students were given drill and practice on material which supported their regular classroom activities. In computer literacy activities, students were given instruction in computer programming, mostly in BASIC.

Ethnic minority and lower class students receive a different kind of instruction on computers than their middle class and ethnic majority contemporaries. While middle class white students, especially those who are in GATE programs, receive instruction which encourages learner initiation (e.g., programming, problem solving), lower class and ethnic minority students, especially those in Title I programs and magnet programs, receive instruction which maintains the control of learning in the machine, (e.g., drill and practice repetition of work first taught in conventional curricula).

The Rationale for Computer Use

We asked school officials why they were introducing computers into the school curriculum. Educators' answers included: "we want kids to feel comfortable with computers," "we want students to learn programming . . . it is an important skill," "students can gain control of the medium by learning to program it," "computers can help teach academic subjects," "computer awareness," "we need to raise CTBS scores. . . we think computers can help us do that."

Educators' reasons for acquiring and using computers are not randomly distributed. They line up with the sponsorship of computers and the students who use them (see Figure 1). Computers are used to "raise the test scores" of lower class students (who receive drill and practice instruction on computers acquired through Chapter I and desegregation funds). Computers are used to "enrich the curriculum," and to teach programming and present logical problems to middle class students (who receive learner initiated instruction on computers purchased through GATE or private funds).

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Sierra	700	2 elementary	22
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Conclusions

The following are the major conclusions from our study of computer use in the five school districts in Southern California. Because we focused on a small number of school districts in a circumscribed geographical area, care must be taken when generalizing from our findings.

The most prevalent instructional application of computer use was for basic skill instruction and computer literacy. When computers were used for basic skills instruction, students were given drill and practice on material which supported instruction they received in their classrooms. When students were exposed to computer literacy, they were taught how to program computers, mostly in BASIC. Computers were used for writing, music, and art far less often than they were used for CAI and programming. Like Tucker (1983), we are surprised at this order of priority. First, the full power and range of microcomputers are not being exploited when microcomputers are used for basic skills instruction and programming. There is little evidence to suggest that microcomputers can deliver basic skill instruction better than conventional techniques; and their utility diminishes when their high cost is taken into consideration (Tucker, 1983). Second, the use of computers for basic skill instruction and programming does not match the needs of the world of work, where microcomputers are used for text editing, spread sheet analysis, and data systems management. As school districts become more familiar with the strengths and limitations of microcomputers, we hope that educators establish the uses of microcomputers based on educational objectives and not simply preliminary perceptions of what the computer can do.

Access to computers and computer use was differentially distributed. Ethnic minority and lower class students receive a different kind of instruction on computers than their middle class and ethnic majority contemporaries. While white middle class students, especially those who are in GATE programs, receive instruction which encourages learner initiation (programming and problem solving), lower class and ethnic minority students, especially those in Title I programs or magnet schools receive instruction which maintains control of learning in the machine (computer aided drill and practice). The tracking of students from different socioeconomic backgrounds through different computer based curricula stratifies students' access to information technology. Differential access represents one of the ways in which the microcomputer can be used as a tool to contribute further to the stratification of our society. If only a few people learn to control computers, then we will have a system of stratification based on technological capital that will make the one based on economic and cultural capital look pale by comparison.

The most prevalent placement of computers was in central computer labs. This configuration either represents a change in school policy since Sheingold's (1981) study, or suggests that we do not have a representative sample in our study. Microcomputers were seldom found in classrooms. When teachers did integrate computers into their classrooms, the computers had been at the school site for a number of years, and the teachers were highly motivated and/or were very knowledgeable about computers and their use. Furthermore, these "computer buffs" (Sheingold, 1981) had links to local computer clubs, professional computer using organizations, or to a university.

These school districts spent very little of their own money to acquire

computers, which is not the prevailing national norm. This finding may be unique to the districts we studied, or it may be a function of Proposition 13, the tax initiative which reduced the money available to school districts in California. Although these school districts relied on state and federal money which was designated for certain students to acquire computers, observation of computer use through time shows that computers are not limited to the groups for which they were acquired originally. After a year or two, computers acquired for GATE students begin appearing in regular classrooms, a finding that both shows the diffusion of computer use, and the ability of school districts to find adaptive solutions to pressing educational and fiscal problems.

Will computers last in schools? Or, like other highly promoted educational innovations such as educational television or the new math, will they have a short lived existence? In evaluating the life expectancy of computers in schools, it is important to keep in mind that the impetus for their acquisition comes from sources which are external to the school. Computer manufacturers, computer using businesses, and parents, fearful that their children will not develop skills needed in a technologically dominated marketplace, pressure schools to teach students about computers. These pressures highlight the relationship between schooling and the world of work. Schools' reaction to this relationship may very well determine whether computers stay in schools. If schools adapt their curricula to meet, indeed even anticipate the uses of computers in the world of work, then we can expect computers to be a viable part of schooling. Their viability will be increased to the extent that their impact on all aspects of the social system of the school is anticipated (Sarason, 1982). If, however, schools continue to use computers as the majority of them are--as fancy teaching machines for basic skill instruction through drill and practice--then we can expect computers to recede in importance in schools. People will learn the more compelling use of computers, e.g., text editing, spread sheet analysis, data management, music and art from sources outside the schools. If people turn away from schools to learn about information technology, then this social movement will have a profound impact on the structure and function of school as we know it (Illich, 1970).

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APPENDIX III

Education and Ecstasy:
Computer Chronicles of Students Writing Together

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To appear in: Quarterly Newsletter of the Laboratory of Human Cognition, Vol. 5, No. 3, July 1983. Special thanks to Bud Mehan for his many useful comments on earlier drafts of this paper.

Education and Ecstasy:
Computer Chronicles of Students Working Together

There are, around us, forty learning consoles, at each of which is seated a child between the age of three and seven face outward toward the learning displays...When the child takes the chair to begin learning... the central learning computer plugs in that child's learning history. The child watches his most recent lesson reeling by on his display. If he wants to continue where he left off, he holds down his "yes" key... If not, he presses "no," and the computer begins searching for material appropriate to the child's level of learning (Leonard, 1968).

Leonard, one of the progressive educators of the sixties, believed that the process of learning was ecstasy and that many of the schools of the time were robbing children of that ecstasy. Building on the ideas of Dewey, he asserts that education is an interactive process through which the learner is changed. Children who are actively involved in learning activities that they find meaningful, and have some control over, will discover, Leonard claims, the ecstasy in learning. Looking into the future, he envisioned how the use of computers at the end of this century could extend his notions of self-directed learning. The scenario he created gives students control over the timing and pacing of their lessons but does not extend to ways that the computer itself could be used to accomplish the form of education that he describes so well in the rest of his book. His vision of computers in education lacked crucial interactional dimensions of learning that he describes in his own writing. It left me with a dread for the coming of the computer age. Were our children to be taught programmed sequences of information over which they had no control other than to respond correctly or incorrectly? Would children be socialized by machines and as a result become more machine like? What would happen to the development of interactive skills? Would computer dialogue be the model for human interaction? What would be the role of others in this form of education? Where was the ecstasy in this model of instruction?

These were some of the questions that plagued me when I read Leonard's scenario over a decade ago. The computer age is now upon us and rather than dread, I find myself eagerly implementing a computer curriculum in what we call a "Mental Gymnasium." While there are certainly similarities between Leonard's early vision and what is happening in classrooms using computers and in programs like the Mental Gym, there are many important differences. Foremost is that the forms of social interaction that the computer can facilitate go far beyond what was imagined. Rather than limiting social interaction the computer opens new possibilities for cooperation and cooperative learning. Studies of classroom use of computers have shown that the computer facilitates more not less interaction among students than similar activities without the use of computers (Hawkins, 1983; Riel, 1982).

The advent of the "personal" computer gives children far more power over the technology than Leonard envisioned. Rather than being controlled by the

computer and programmed sequences of instruction, children are learning how to make the computer serve their own purposes. Students working together to accomplish their own goals can help them experience the ecstasy in education that Leonard describes.

I am fairly certain that Leonard's current vision for the use of computers in 2001 would be very different than the one he wrote in 1968. I am not able to look as far into the future as he did, but I can describe some current history. In this paper I will discuss the development of a social network utilizing computers -- a children's news wire service -- and its influence on reading and writing skills and the social dimensions of learning.

The theoretical motivation for the Mental Gym project come from many different traditions. From social and cognitive science we learn that social and cultural systems are important for the development of cognitive skills. Yet schools do not fully exploit social resources for learning. Since social interaction often involves people with potentially diverse goals, we assume, at the outset, that the goals of the learners do not necessarily match those of the teachers. An approach to education that makes social interaction central must address the educational goals of both teachers and students. In following section I will discuss the role of social interaction in cognitive the development and ways that social interaction could be more centrally integrated into educational activities.

Social Interaction and the Development of Cognitive Skills

Humans are social beings and carry out their work in concert with other people, yet most studies of cognitive processes are carried out with an isolated person (Norman 1981). We know little about how people carry out cognitive activities in social interaction.

Social interaction, itself, is a process of coordinated sense-making of the actions of ourselves and others. Since no two people share exactly the same experience, social interaction must be a constructive process of understanding and interpreting (Schutz, 1962; Garfinkel, 1967; Cicourel 1973; Mehan and Wood, 1975; Mehan, 1983). This means that all participants in even the most routine social encounters take an active role in constructing the meaning of the situation. While sociologists have provided us with many insights into understanding the processes of social interaction, they have seldom looked at the developmental acquisition of the skills needed for interaction (Cicourel, 1973).

Interaction between adults and children is different than interaction between adults in that the adult has a richer interpretation of both what the child knows and needs to know. However children, like adults, are actively constructing meaning from their encounters with others. The developmental work of Piaget and Chomsky has documented the powerful role that children play in developing meaning, while Vygotsky, Dewey and others emphasize the role of adults in this enterprise.

Piaget lays out a developmental progression of intelligence that is based on the children's internalization of their interactions with the

physical and the social environment. While Piaget asserts the interdependence of social and individual activity, the role of social interaction in the development of cognition is not addressed directly by him or in the research tradition that he has inspired. In contrast to Piaget, Vygotsky focused on the social and historical influences on the development of cognition. Vygotsky makes the even stronger claim that the mental organization of the mind is highly influenced by patterns of social interaction.

While there are important differences in these research traditions, they share some important assumptions in common. They all assert that interaction is a constructive process in which participants engage in a process of creating understandings. These understandings form the mechanisms of thought. Knowledge is activity and development is the process of internalizing and organizing these activity patterns. Since humans are essentially social, these activity patterns routinely involve interactions with others. Schools, however often set up learning activities that are highly individualistic, thereby ignoring an important resource for learning.

In this paper I will be describing a social system for the development of academic skills. The goal of this project was to explore the social dimensions of learning, encouraging children to participate in the construction of learning environments that alter their interpretation and understandings of their world. The interactive capabilities of computers and students' high interest in them make computer-mediated learning environments ideal for achieving this goal.

THE MENTAL GYMNASIUM: AN EXPERIMENT IN COOPERATIVE COMPUTER LEARNING

We wanted to create social learning environments that provided dynamic support to students participating in meaningful tasks. We chose to work with children that were below grade level and having difficulties in school because the most common approach to teaching these children is to break a task down into smaller and smaller units. Our theoretical interest in the social influence on the development of skills suggest an alternative approach. This was to engage these students in whole tasks and yet provide them the support they needed to begin to work productively. We wanted to help students create their own goals which would help them acquire the skills they were finding difficult to learn in their regular classrooms.

Using the theories mentioned above and the strengths of different models of education (Kohlberg and Mayer, 1972) as guides, we have been developing and experimenting with educational software systems to provide dynamic support in learning activities.

The bulk of the educational software available for personal computers falls in the category of "computer assisted instruction." This usually means drill and practice with immediate feedback and self-pacing. This use of computers is based on an educational philosophy that Kohlberg and Mayer (1972) describe as a "Cultural Transmission" model. In this model of education, the material to be learned and the sequence in which it is learned is rigidly fixed by the teacher and the materials.

There is another instructional application of computers that includes the "discovery" or learning tools such as LOGO, The Bank Street Writer, Rocky's Boots, and a variety of games that help the player understand

concepts that are important in math, science, language or other curricula. This software is based on the educational philosophy that Kohlberg and Mayer refer to as the "Romantic Model." In this approach, that learner is placed in a very rich learning environment but is given very little guidance in terms of what to learn or how to proceed.

The strength of programmed learning sequences and Computer Assisted Instruction is that detailed help and direction is provided. The weakness is that learners are so thoroughly guided through the small pieces of the task that they may lose sight of what they are trying to do. The danger is that they will learn that learning is simply repeating the steps that the teacher provides. By breaking the task down into small tasks, it leaves the students the difficult task of reassembling the pieces to make sense of the whole activity. It also frequently ignores the goal structures of the learner by trying to supplant them with the goals of the teacher.

The strength of software which promotes discovery is that the learner is exposed to a whole activity and is free to explore and learn in his or her own way. The problem with this approach is the lack of direction that novices need to make sense of the activity. That is, the student may be overwhelmed with the complexity to the situation and give up.

The reason for breaking a task into small steps is so that the individual is not overloaded by attending to everything at once. This is the most reasonable method if the learner operates alone and there is no way to support the learner in the task. An alternate way to arrange for educational activity is to have "the whole task" accomplished in a social setting in which the novices participate initially in restricted ways. By placing the learning of the pieces in the context of the whole task, the learners are not simply learning isolated bits of information, they are learning how that action relates to the task as well as observing what they still need to learn to carry out the task alone. As the learner becomes more skilled the social support can be withdrawn allowing the learner to take over more responsibility for the activity. This notion of dynamic support while participating in the whole task is the method of instruction commonly used in primary socialization for a range of skills in industrialized work settings, and for educational tasks that occur outside of schools.

Before discussing how we implemented this approach using computers, it may be useful to consider a concrete example of dynamic support while participating in the whole task: mothers teaching their young children how to read (Ninio and Bruner, 1978). Young children do not begin with the goal of learning to read. But mother and child sit with a book and carry out the activity of reading. Since the child begins knowing very little about the activity, the book and the mother must carry much of the work of reading. As the child becomes familiar with the patterns, he or she may begin to participate in simple subskills such as turning the pages, or pointing to objects. As the child gains knowledge, what is expected of him or her shifts. Now the child is asked to provide names for objects or to tell what is happening in the story. Slowly the attention is shifted from pictures to text and children begin to recite well learned pieces of the text. Mothers do not start with a fixed notion of the steps or sequence of the learning process. They have some sense of the end point and possible strategies, but their children's behavior will determine the process. The child's skill becomes more and more flexible and over time, the support provided in the book and by the mother recedes and the child is seen as an independent

reader.

The activity of reading the book has remained constant through the whole process. What has changed is the support that the child needs to stay in the activity. This changing network of support has been referred to as the zone of proximal development in Soviet Psychology (Vygotsky 1978) and scaffolding in American psychology (Wood, Bruner & Ross, 1976; Greenfield 1981). The activity that is accomplished in the social setting, "the zone," provides a good prediction of what the child will soon be able to accomplish on his or her own at some future time. In a sense it turns the competence/performance issue as phrased by Chomsky (1965) around so that performance is seen to precede competence (Cazden, 1981).

Learning to do the pieces in the context of the whole guards against a situation in which the learner gets so obsessed with either accomplishing a subgoal or not succeeding in a subgoal that they never understand the relationship of a given piece to the task of which it is only a small part. Attempts to teach reading in school by focussing first on decoding skills, independent from reading for meaning (DISTAR), have the unfortunate outcome of producing students who labor over reading the words aloud and believe that they are reading.

In sum, we are referring to "whole activities" as those in which the goals of the students evolve in a way which will subsume the goals of the teacher. This definition does not mean that the goals of the learner are the same as the goals of the teacher. Rather it means that the activities that children find meaningful in themselves are used to serve educational goals. Just as the young child does not begin with the goal to learn how to read, we didn't expect students to begin with the goal to learn how to compute or write.

The Context of The Mental Gym

We used the concept of a gymnasium to characterize our endeavor as it suggested some important features of the learning environment that we sought to create. Athletic activities that take place in a gym are disciplined yet enjoyable. People go to a gym to practice skills so that when they play competitively they will perform their best. A gym is a place where one can try out new skills as well as strengthen old ones, gaining, thereby, a better appreciation of oneself and one's skills. The experts who offer help in a gym generally recognize that there are many different playing styles and they coach players to discover the optimal match between their abilities and the constraints of the game. And finally, people choose to workout in a gym because they value the results of their work.

By analogy, the Mental Gymnasium was a place where children went to develop and practice mental skills in a disciplined, enjoyable way. There was variety in the set of "mental exercises" that students engaged in, but all the training was directed to the development of basic educational skills. These include reading, writing and arithmetic, as well as problem-solving, memory and planning skills. Students were given as much coaching as they needed to begin working, and as they became more skilled, they were encouraged to take on more and more responsibility for the activities. The students were encouraged to chart their own progress and to set their own goals.

The Mental Gym was organized around four learning centers: reading, writing, math and memory. In the reading and writing training centers the children worked with an interactive text system that enabled them to create their own versions of stories with pictures encouraging them to take an active role in the reading and writing process. One of the major activities at these two centers was working as reporters and editors for the Computer Chronicles, a students' newswire service that we created. It is this activity that will be the focus of this paper as it drew all the children in the Mental Gym into an activity that most clearly approximated the system that we sought to create.

Computer Writing in a Social Context

Writing is often considered to be a solitary task in which the writer translates thought into words for the purposes of communication. Learning this form of communication is one of the many complex tasks that take place in schools. Teachers often have a great deal of trouble teaching students to write and find it even more difficult to encourage students to revise and develop texts.

We know from past research that the use of computers alone would not solve the problem of teaching students how to write (Levin, Boruta & Vasconcellos, 1983). The blank screen can be just as intimidating as the blank page. Students with the most powerful editing system still must approach the task of writing alone. While we were convinced that this new medium, in itself, would not transform students with writing problems into skilled writers, it does present a medium that makes a new social organization for writing possible. This organization, not just the computer alone, had very positive effects on the writing process in the Mental Gym.

The computer facilitated three types of interactions that provided the support necessary to involve students in writing. First, computers enabled cooperative work among pairs of children that is difficult to create using pencil and paper. The presence of an "other" during the writing process facilitated problem solving help in generating ideas and immediate responses to the written text. Second, since computers are interactive media, they were used to provide the student with a great deal help with pre-writing or idea formation. This made editing much easier and provided for efficient storage of text for later revision and editing. Finally, computers were used to create functional writing environments, those with a purpose and audience for the stories that students created. When students realized that other people would read their work, not just to evaluate its form, but instead for its content, they took a very different approach to writing and actively engaged in the revision and editing of their own writing and the writing of their peers.

Cooperative Peer Writing and Revision. Students in the Mental Gym always worked on the computer in teams. This contrasts with conventional arrangements for writing as a solitary activity (Britton, Burgess, Martin, McLeod, & Rosen, 1975). Many people have suggested the value of collaborative writing, but it is difficult to share a pencil or to write a text collaboratively on a piece of paper. It is much easier to divide up the work of writing on a word processing system. The display is more public and legible, the keyboard extends in space more than a pencil, and some writing actions (capitalized letters, special punctuation marks) require simultaneous multiple keypresses. Students in the Mental Gym and in other classrooms

(Levin & Boruta, 1983) spontaneously come up with many different ways of dividing up the work of writing collaboratively.

One of the values of cooperative peer writing is that it provides social resources to confront the blank screen. Even when neither student began with an idea of what to write, the discussion of the problem often presented the solution. In the process of entering the text, the student that was typing was often concerned with local issues such as the choice or spelling of a word. The other student often took this time to determine if the larger unit, say the sentence, made sense and what should come next. Working alone, students often find it difficult to concentrate on the choice of a word without losing their overall plan of writing. Working together, students distributed the task of writing, and helped each other when they had problems.

An equally important function of cooperative peer writing was the immediate audience (the partner) who responded to the text as it was being written. Students frequently challenged one another's sentences as "not making any sense" or corrected the spelling of a word as it was typed. Less frequently, but more importantly for the writing process, the students discussed whether two sentences should be conjoined, how run-on sentences should be divided, or how to substitute for overused words. Incomplete idea fragments produced by one of the students were often completed by the other. Research indicates that response to student's writing by peers or teachers results in sufficient increases in the quality of writing (Cooper, 1974; Diederich, 1974). This kind of on-line evaluation is likely to be even more effective than seeing red marks on a paper long after it is written. Students working together were able to provide the kind of individual help for each other that was not commonly available in writing activities in the classroom.

Interactive Texts. The way the computers were used to help support writing in the Mental Gym was a very important element in creating the kind of supportive environment discussed earlier. A Pascal word processor, "The Writer's Assistant," developed in previous research (Levin, Boruta & Vasconcellos, 1983) was used with these children. While students were very excited about using the computer to write, it did not provide enough help for the writing process. Text editors are general purpose learning tools and as such do not provide for the kind of guidance necessary to help students in the writing process. For this specific task we used a special purpose programming language to create "Interactive Texts" that explicitly shared the initiative for interaction with the learner (Levin, 1982), which enabled us to provide students in the Mental Gym with a dynamic range of support for reading and writing.

This system made it relatively easy for the coaches in the Mental Gym to leave personalized messages to students regarding their progress. It also gave the students a range of options and activities to help them in the reading and writing. When students were assigned to write newspaper articles, the computer support system began by helping them narrow that task down to writing in one of the sections of the newspaper (or to create a new one). If students knew what they wanted to write they would begin writing. If they were unable to think of something they had the option of asking for more help. The computer was used in this activity to provide suggestions of topics, headlines, organizing questions. In other writing activities it provided opening sentences, pictures and sample stories. Maximum support was

provided in writing assignments by giving the students a series of options to select among to produce their "own" version of a story. In these cases interactive reading was the first step toward interactive writing.

Writing in response to prompts was very helpful in dealing with the initial blank screen, but often didn't result in fluid text. The responses to prompts and suggestions left the student writers with a rough draft of a story. At the end of this "pre-writing" process, the students used "The Writer's Assistant" word processing system to edit their work. We developed prompted activities in the domains of descriptive, narrative and expository writing, as well as poetry and letter writing.

Functional Writing Environments. One of our strategies for dealing with the writing difficulties of the students involved creating a "functional" writing environments. Functional writing environments are those in which writing is organized for communicative purposes, rather than just as an exercise for a teacher to evaluate.

Many students (and many adults) are much more skilled at sharing their ideas in verbal interaction than in written text. Their own goals often do not place much emphasis on writing, much less mastering the social conventions of writing. They see little purpose in it. To counter this decontextualized approach to writing, we created a functional system for reading and writing that provided an audience for information exchange. This audience was one that the students were unable to communicate with verbally, but was one with which they wanted to share ideas. We created a students' "newswire" service known as The Computer Chronicle Newswire. This network made students' concern with the mechanics of writing secondary to, but instrumental for, communicating clearly. Within this framework, we were able to explore more fully the influence of "audience" on students' writing and revision.

Computer Chronicles Newswire

The Computer Chronicles Newswire was a writing network that integrated a computer-supported writing system, cooperative problem solving, and newspaper reporting into a larger network of communication. The network was set up with the help of Jim Levin (UCSD) and Ron Scollon (University of Alaska). It began by linking together five schools, two rural and one city school in Alaska and one suburban and one rural school in California. Each classroom generated and edited articles stored on floppy disks, which were sent out to all the other classrooms. Each classroom chose the articles they wanted for their own local version of The Computer Chronicles Newspaper. The news network was explicitly modelled on the international news wire services that are important to adults. Whenever possible we helped students to see the parallels between their work and the work of newspaper reporters and editors.

This network enabled students who knew nothing about each other personally to share conceptions of their lifestyles and worlds. The differences among the lifestyles of the participating students made it important for the students to write good descriptive accounts of their everyday activities. The students who participated in the network enjoyed the contact with students in other locations and soon requested that we extend the network to include their favorite city or country.

The children who came to the Mental Gym to work on reading and writing

difficulties became reporters and editors responsible for the production of the Mental Gym version of The Computer Chronicles. These children began working on the computer with some vague notions of a newspaper and of sending stories to kids in Alaska, New York and other places. Their understanding and interest grew as they became more aware of what it meant to participate in such a network.

This functional writing system contained a number of crucial features. The Computer Chronicles Prompter, an interactive writing system was developed to give students prewriting help in making decisions as to what to write and to help them organize their ideas. Students always worked in teams either to generate new articles or to edit those received from other students. In addition to computer and peer support in the Mental Gym, the students had the help of "computer coaches". The coaches at the gym were university undergraduates who knew very little about computers but who could provide encouragement and serve as "adaptive experts" when problems arose. Another important element of the writing environment was the Editorial Board Meetings which were held to determine which articles would be accepted for their newspaper. The students' production of the Mental Gym version of the Computer Chronicles was the explicit goal that organized their activities, although they were just as eager to see their stories published in The Computer Chronicles produced by each of the schools.

Writing Skills in the Mental Gym

What have we learned from our efforts in the Mental Gym? What can we say about change in students' writing abilities when students participate in this type of a network? While the changes in our posttest measures after a few months were not striking, the change in the students' attitude towards reading and writing were (c.f. Center for Social Organization of Schools, 1983). The children regularly showed their work to both their classroom teachers and parents. The students eagerly took stories home to read and evaluate and in some cases spent time at home preparing for their work in the Mental Gym.

The Mental Gym worked with eight students and although all participated in the Editorial Board meeting, reading and evaluating stories, they did not all work on writing and editing articles on the computers. Each pair of students were referred to the Mental Gym to work on specific skills. The students working at the math center did not do any writing or editing on the computer. The students from the Reading and Memory Centers each spent part of their time writing and editing stories, while those at the Writing Center spent more than half of their time in the Mental Gym working on newspaper stories.

Pre and post tests were given to measure quantitative change in the students' skill. We were most interested in looking more closely at the process of change. The computer stored all texts the students produced and "keystroke" data on all writing and editing. Each session with the computer was audiotaped and observational notes were kept on the students' interactions with the computer, each other and with computer coaches. This enables us to examine closely the process of writing and the kind of errors that students made and corrected. While some of the process data is still being analyzed, the following findings indicate the effectiveness of this computer network on the development of writing skills.

Pre- and Post-tests. All students in the Mental Gym who worked with the computer interactive writing and editing system were given a writing pre-test. A prompt for expository writing was chosen because this form of writing is not routinely focussed on in the classroom and would be important in writing for a newspaper. The pre-test writing prompt asked students to describe an activity in the classroom.

Think of some thing you do regularly at school. It could be anything, like how you do your reading or math lessons, getting ready for the beginning of classes, the way you go to the library or lunch, something that happens at P. E., or any other thing you do at school. Imagine a new student is coming to your school and wants to know how to do this activity. Think of how you do this activity. Think of what you do first. Then think of what happens next, then what, and what happens last. Think of all the steps in order so you can write about it.

The post-test was identical except that the students were asked to write about something they do at home. And, instead of a new student, they were told to imagine that a student in Alaska wanted to know about what they did at home.

The stories written for the posttest were longer on the average (79 vs. 53 words per student). The difference is greater if we look at the number of words that were used to directly describe an activity (63 vs. 29 words per student). Several students in the pre-test spent most of their time writing about "the new student" and very little time describing the activity. In the post-test they all moved quickly to the task of describing the activity.

These comparisons indicate improvement in the writing skills of these children over a half year period. We are currently looking at measures to see if there are qualitative changes in the writing samples. It appears that for some of the children there were clear signs of improvement while for others the quality is about the same. Without a control group, it is difficult to argue that any of these changes are due to their work in the Mental Gym. These results are, however, consistent with previous research which indicated that students writing with computer produce longer texts while maintaining similar levels of quality than children who do not use computers (Levin and Boruta, 1983).

The most striking difference observed is not captured in these measures. When the students were given the pre-test, they complained about it, needed to have it read many times, in some cases needed an adult to sit next to them prompting them to select an activity, think about it and finally write something. The students did not write easily and, if it there had not been the promise of working on the computer, some of the students may not have cooperated.

When the post-test assignment was read the students picked up their pens, asked a few clarifying questions and began writing. No one complained and the prompt did not need to be repeated. The students' attitude toward writing had changed. They were more confident of their ability to write and had a better understanding of the need for explicit description. The students, themselves, in individual interviews often commented on how The Computer Chronicles had helped them learn how to write.

Reporting from the Mental Gym. Most of the Computer Chronicle stories written in the Mental Gym were produced by the two students who were selected because of their difficulties in writing. One of the students, D, was referred because he routinely failed to turn in writing assignments and because he had great difficulty in writing. The other student, H, was described as having trouble with the mechanics of writing. Our pre-test writing samples were consistent with teacher reports. D took a very long time and needed much prompting to complete a task. He wrote very short sentences, but they were directly related to the topic and made very few errors. H had less difficulty putting words to paper but he had trouble staying on a topic and his syntax and spelling were poor. The students had complementary strengths and weakness which we felt would make them a good working team.

The students spent the first two weeks learning how to use the computer, using a typing tutor program to help them learn the keyboard, and interacting with story makers to help them learn how to use the interactive system. The students began writing stories for the Computer Chronicles in the third week of Mental Gym.

During their first month, the students wrote five stories for the Computer Chronicles. Four of them were composed at the computer with the support of the computer prompting system, each other and a UCSD undergraduate who was serving as their computer coach. The average length of these stories was 24 words and they generally did not provide much useful information on a topic. The fifth story was a collection of jokes for the fun section of the newspaper. The students had borrowed a book of jokes from the library to use to help them think of jokes. The jokes were entered during the same period of time as the other four stories but contained a total of 98 words. This is important because it demonstrates that the limited length of these early stories was not due to a lack of computer or typing skills. The students simply did not know what to write and needed a great deal of prompting to get started. The observational notes from this early period indicate that both students were excited about writing on the computers and worked very hard to generate stories but needed help in determining what to write, the same problem the teacher reported about their classroom work.

As the students received stories from other schools and they began to get a better idea of the news network, the length and quality of their stories began to increase. During the second month, the students wrote seven stories and the average length of each was 78 words, almost triple what it had been during the earlier period. The stories improved in quality and the students were much less dependent on their computer coach for help in the writing process. The coaches began to take a more distant role spending their time taking notes and encouraging the students to turn to each other or to a dictionary for help.

During the final month, the computer coaches were phased out and the students worked alone at the computer. The students wrote seven stories during this period and the average length per story was 68 words and these stories provided adequate information about the particular topics. The stories of this period are not much different from the second, but now the students are able to do this work with almost no adult guidance. They have taken over the role of asking each other questions and thinking of what needs to be said to tell other students about an activity. The change is not in

the level of skill but in the students' ability to handle more of the task themselves.

Another important area in which we saw change in the writing process was in the students' attitude toward editing. As students worked on these stories, editing became a routine practice for them. When students located errors made earlier in their text, they were not discouraged. They indicated that they would correct it when they were editing. This sense that errors could be easily corrected at a later point encouraged fluency at the early stage of the writing process. When the students first started working, they obtained a printout of the article directly after the first draft. As editing came to be an accepted second step, they no longer obtained printouts of their early draft, but waited until they were finished editing the story.

A further indication that editing was becoming an expected part of any writing of these students came from D's posttest. When I came over to check how he was doing, he said, "Oh, I'm finished writing, I am just editing now".

The Editorial boards provided the kind of feedback that helped them understand that revision is also an important part of the writing process. At the very first editorial meeting the students had rejected two and three sentence stories about sports because they lacked details and accepted one story about soccer that described the goal of the game and gave a description of how the game was played. When these students' story on Coneball (written during the early period) was about to be read, the authors "pulled" the article and said that they would fix it. They saw their own writing in the context of the evaluative framework that they had help create. It was not acceptable and they knew it. They also had a good idea of how to fix it: it needed more details. They revised the story and in a later board meeting it was accepted for the newspaper. They were as pleased as we were that they had fixed it themselves without having anyone tell them what needed to be done.

The students worked cooperatively and benefitted from each other's skills. When I asked each of the students alone what they learned from the other student, both D and H indicated that D had helped H with spelling, a point confirmed by our observers in the Mental Gym. However, towards the end of the session, on at least two occasions, H had corrected D's spelling marking the occurrence with great pride.

Since our notes indicated that H often took the initiative at the beginning of the sessions, we assumed that H took a more active role in determining the topic of writing. When asked about this, H disagreed, saying that before they came to Mental Gym they would get together and talk about what they would write about. Sometimes they looked around the classroom for ideas; one time they went to the library for help. I asked him where the idea for a recent article on the San Diego Padres had come from. He said that he got the idea while watching baseball over the weekend and they both thought it would be a good story.

This emphasis on "team" rather than individual work was also evident in D's interview. He had listed language and reading as his least favorite thing to do in school and writing and editing for The Computer Chronicles as his favorite activity in the Mental Gym. When asked to explain this apparent contradiction, he said that he didn't like writing in the classroom "because your hands get tired after about three sentences and you feel like just

leaving it." In contrast to writing in the classroom, the cooperative activity in the Mental Gym was fun because "Me and H are a team, we get to do it together. In the class we don't get to discuss anything. H gives me ideas."

These students worked exclusively on interactive reading and writing programs in the writing center. Although some of the story making activities did include graphics they were not given any "games" to play. In all of the other centers which were clearly visible to them, educational games were routinely used to provide practice in the concepts learned. We had selected some "game" format activities in writing that we could use if the students complained, but we wanted to see if the interactive text system could compete successfully with these other games. The students worked enthusiastically and only asked once over the twelve week period to do any of the other activities. They asked to work with Musical Spell (a spelling exercise that maps musical notes to the alphabet) the week that it was introduced to the other students. They were given that option several times and played the game for two half hour sessions. For the rest of the time they were content to work with "words." In fact, the students from the math center asked on two occasions to be permitted to edit stories for the Computer Chronicles! This together with the students' own reports indicate that the students enjoyed writing in this functional setting.

The classroom teacher indicated that both students wrote more easily in the classroom, although she was disappointed that she did not see more improvement in H's spelling. She reported their changed attitude toward writing as the most noticeable change. They brought her every story they wrote to look at and were very proud of the finished newspaper.

Twelve weeks is a relatively short time in the life of students, but in this time we were very pleased with the amount of change we saw in the work of both students. Their positive approach to writing as a form of communication, their understanding of the need to edit and revise and the value that they placed on knowing how to spell correctly are all likely to lead to continued improvement in writing skills.

We were able to create a learning environment that began by providing them with as much support as they needed to write. In this supported system, their writing improved steadily. At the end of the session, we were pleased to see them continue to work at this level but relatively independent of adult guidance. In this way we were able to create the kind of system described earlier in which experts and novices begin an activity together with the experts doing as much for the "novices" as is necessary to create the joint activity, and then systematically removing the help as the student demonstrates skill.

Editorial Board Meetings. We also saw individual development of the students' writing skills from participation in the Editorial Board Meetings. When stories came over the "newswire" from other schools, the students were eager to read them and express their views about which ones were good stories. All the students willingly gave up part of their recess to participate in Editorial Board Meetings to read and evaluate stories. This voluntary participation during their time is a measure of interest of the students. This willingness to do reading and editing during "recess" time is somewhat surprising, in that students who are having trouble in academic subjects have been found to be extremely skillful in avoiding situations in

which this trouble might be made more evident (Riel, 1983).

Each story from the news service, including those written by students in the Mental Gym, were read by one of the students. Then the group made a decision either to reject the article, or to accept it with or without revisions. A decision was based on a majority vote plus a formulation of a "good" reason for its acceptance or rejection. The role of the adult coach was only to record the results and to judge whether or not the reason given was acceptable. Otherwise, it was their meeting.

The students began with simple reasons such as "too short" but soon found a short article that was acceptable because it had "good details." The students quickly determined whether they liked or disliked a story but they were less aware of why they made these evaluations. Having to find a reason helped them understand their evaluations.

The students were also proud of their ability to locate errors and fix problems in the articles written by other students. When a story was found to need editing, all the students wanted to be the ones to edit it. Contributions of stories written by some of the students in Alaska for whom English was a second language gave the students practice in correcting a variety of grammatical errors. Students felt a real sense of accomplishment when they improved articles written by other students. While they were well aware that their own writing skills needed improvement, editing these articles helped them see that they had skills that other children found difficult.

The major concern of The Editorial Board was that an article "make sense" as well as be well written. When they edited stories they combined and divided sentences, removed redundant information and tried to finish incomplete statements as well as correct spelling, capitalization and verb tense errors. When students were satisfied with an article, it was accepted. Since students saw this as their newspaper, they collectively worked to improve the articles.

While students' evaluation and editing were improving, there was another important kind of learning taking place. Students were learning about life styles and customs that were very different from their own. This provided them with a new perspective on their own lives. They began to understand how their culture was both similar and different from that of these other children. It provided them with direct communication with other children so that they could share the information that they felt was important.

They were also beginning to understand the role newspapers play in a society and how such communication networks function. Students were forming their ideas about what makes a story "news worthy." They were dealing with issues of what is appropriate and inappropriate writing for this media. A few examples from the Editorial Board Meetings will illustrate children struggling over these issues.

A story describing a family opening presents on Christmas morning was received in January from a student in Tununak, an Eskimo village on the Bering Sea in Alaska. The first reading of the story lead to concerns over grammatical errors, and a pair of students quickly volunteered to fix it. They fixed some of the errors and removed sentences that were redundant. The story came back to the Board and space constraints on the layout of the page

lead to the discussion of its content. One student argued that the story should not be accepted because it did not tell any news. It just told about what everybody does on Christmas Day. Another student agreed but then a third student volunteered that not everyone celebrates Christmas in the same way. For example, he argued people in Africa don't do the same thing therefore this Alaskan story was news. Students were persuaded by this argument until someone else reflected that children in Africa would not see the newspaper. The final decision was not to make extra space for the article but to hold it for available space. The students had discovered the use of a "filler" story.

Another story entitled "Helping" was about two people named Charlie and Claire. In the story Charlie tells Claire to do things and Claire does them willingly. Some students saw Charlie as the husband of Claire and others saw him as her father. In either case, the students argued that it was not a story about helping, but instead was a story about bossing. They all quickly agreed that they did not approve of Charlie's behavior and did not want that story in THEIR newspaper. When pressed for a reason for rejecting the story, they said the story did not match the headline and that bossing wouldn't be a good topic for a story.

Another problem arose when one student raised concern over a joke that had come from another school:

Knock, Knock.
Who is there?
Madame
Madame who?
Madame foot is stuck in the door.

A student was concerned over the "bad word" in the joke. At first all the other students disagreed because of the spelling. The one student was persuasive enough to change the minds of three students for a tie vote. At a later session the question came up again. Some students had asked neighbors or parents for their opinion. The final decision was not to include the joke as some people might not like it although all the students agreed that they thought the joke was funny. Again, students were making the same decisions that editors face as they decide what is and is not appropriate to print in newspapers.

To summarize, the Editorial Board Meetings served a number of important functions. They set new standards for stories that students would write in the future as well as guides for how old stories might be re-written. They provided motivation and suggestions for the editing of stories. Topics of other students provided ideas for future articles. The students learned about themselves and others through the medium of print. They began to understand why people write things and what makes a story interesting to other people. This last issue became particularly salient when the students saw which of the stories they had written appeared in the Tununak, Wainwright, Vista or Fairbanks editions of the Computer Chronicles.

All the students in the Mental Gym dealt with a range of issues from grammatical problems to concern for the content of the articles. But more important, the educational goals of teachers (reading, writing and revision) were being accomplished while students pursued their own goals of creating a written record of what they were sharing and learning from their distant

peers. Even though the computer and the computer software were integral parts of this system, it is important to note that much of this learning took place in group discussions with printed texts and pencils.

CONCLUSION

The theories that have framed this project all describe education as a constructive process that results when the learner takes an active role in interaction with his or her environment. After more than a decade, a rereading of Leonard's book indicates that he shared this conception of education. He describes education as a process of change that comes from interactions with the environment shaped by culture yet internally driven. Ecstasy is the joy and delight that accompanies that change. Throughout his book, he tries to explain what he means by ecstasy, but in the last pages of his book, he uses a personal story to convey how learning that is creative results in ecstasy. At the age of fifteen with the guidance of a friend, he built his own radio. When he finally soldered the last connection and solved all the problems, he reports:

...a universe poured into my room from the star-filled night. I spun the dial: a ham in Louisiana, in California; shortwave broadcasts from England, Germany, Mexico, Brazil. There was no end to it. I had put our new sensors. Where there had been nothing, there was all of this.

Ecstasy is one of the trickier conditions to write about. But if there is such a thing as being transported, I was transported that night. And I was, as with every true learning experience, forever afterwards changed (Leonard, 1968:239).

I think the students who have participated in the Computer Chronicles network, those in the Mental Gym and those as far away as in an Eskimo village on the Arctic Ocean, have experienced this sense of ecstasy. I don't think that this excitement was the sole result of working with the computer any more than the excitement that Leonard expressed resided in the soldered connections in his radio. In both cases the technology is a means of communication. It is the control over the technology, and not the technology itself, that leads to ecstasy. Leonard learned how to build his radio by working closely with a good friend. It was this friend that provided the support, encouragement and sometimes critical clues as to how to continue. When the radio finally came to life, Leonard experienced a sense of accomplishment, made possible by his interactions with his friend, but that now had become his own.

The students that we worked with experienced a sense of power and control over the medium. The computer was a tool that they used to help them share life experiences of children who were living in a world very different from their own. Writing and reading, editing and revision became means to serve this goal. The students helped one another and received help from the computer program and the computer coaches. But like Leonard's radio, their newspaper had become their own.

It was not just working with computers, but the sense of control over the computer, their use of the computer to create a direct link with other children and the sharing of their ideas and lives in print, that resulted in expressions of ecstasy.

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APPENDIX IV

Computers In The Classroom: The Development of Computer Use

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October 1983

Special thanks to the five teachers and their students for their cooperation and patience with this study.

Computers In The Classroom:
The Development of Computer Use

The computer has provided schools with a challenge: How should this new technology be implemented? While there have been many surveys of computer use, (Shavelson, 1981; CSOS, 1983; CUSG, 1983; Miller, 1983) there have been few which have followed computer use in classrooms over time. In this study, we have attempted to capture the process by which the use of computers develops over time in classrooms. We were especially interested in developments and changes in the interaction which takes place between the computer, the teacher and students. With this information in hand, perhaps we can better implement computers into the classroom and maximize the benefits of this powerful new technology.

The Teachers & Their classrooms

This study focused on the ways in which five teachers (BR, MQ, BM, KW & CS), who had little or no experience with computers, introduced and used Apple IIs in the classroom. All shared some common fears concerning the use of computer in the classroom: Would they need to program? Could they use them? Could their kids use them? Despite such fears, for various reasons these teachers decided to pursue the use of computers in their classrooms. Indeed theirs was a "grassroots" effort (Sheingold, 1981).

These teachers had different experiences with computers and operated under different constraints in their classrooms. KW and CS had recently begun to use computers in their 4th grade classrooms. KW's rotated every two weeks through four other classrooms. CS taught at the same school and was adjacent to BM. BM taught 4th grade and had recently begun using a computer in her class. BR taught a 3-4 class and his use of computers was followed for one year. BR's class was unique because it was the site of university research focusing on writing and estimation. The K-1 teacher, MQ, had been recently assigned to this grade level and had used a computer for one week in her previous 4th grade class. MQ, BM, and BR have all emerged as expert computer users. Through their own reports, observations conducted in their classrooms, and interviews, it is possible to chart the development of computer use in these classrooms including changes in activities, organization, and teacher goals. In all classrooms described, personnel from the university served as a resource, providing them with technical assistance and providing them with access to software.

Initial Classroom Computer Use

Initially teachers were concerned with technical and managerial aspects of the computer as well as computer activities. The first issue the teachers had to address was their own mastery of basic computer skills. They learned to "boot the system," copy disks, restart errant machines, and explored the peculiarities of the software (Quinsaat, 1981; Rowe, 1982). The successful integration of this powerful tool into their classrooms was a challenge to these teachers, especially since the computer was unfamiliar to them.

Teachers either acquired such information on their own time or they learned the information from others (teachers or UCSD researchers). None of

the five teachers in this study learned basic machine operation via a formal course on computers.

Teachers also had to consider the effects of introducing a computer on classroom organization. Teachers had to carefully consider how to integrate the classroom setting to avoid chaos and unhappy students. The placement of the computer in the room and student scheduling needed to be addressed.

In the classrooms studied, the computer was usually situated on a cart or desk near a wall. Location proved to be a more complex issue than the teachers first imagined. For example, the K-1 teacher, MQ, reported that a barrier had to be constructed around the computer to keep inquisitive students from being distracted when the computer was in use. Another teacher, BM, had to find a lower table to reduce the height of the key board for typing.

Computer use was scheduled in the mornings, usually during reading and math sessions. Students were scheduled to work in pairs and occasionally in groups of three.

BR described why he had pairs of students work in the mornings as follows: "Since a good part of each day would be influenced by all the switching around of reading groups, it was natural to fit the computer into the rotation" (Rowe, 1982). Afternoon sessions, were not used for computer instruction very often. BM explained, "My class works in small groups in the morning [when the computer was scheduled]. Since the afternoon is the only time I have the whole class together... I like to schedule activities for the whole class." With the exception of the K-1 class all students rotated according to written schedules. The K-1 teacher had some unique problems scheduling computer use. There was a marked difference in the way she scheduled the computer from her previous 4th grade classroom. BQ noted that "the change in grade level required that the organization for using the computer be different, since the children can't tell time, can't read to figure out a schedule and are less likely to be able to work independently" (Quinsaat, 1981).

Once each teacher had resolved the management issues to meet their unique classroom conditions, they had to select specific computer activities and organize the sequence of presentation. The activities selected varied considerably. The most common was an unsequenced approach. Here, MQ, CS, and KW provided the students with a variety of disks containing a range of software. Students were free to choose any activity from the software provided. The activities provided ranged from educational games to microworld simulations. But "tool" activities (e.g. word processing) were absent.

BM and BR's approach was different. BM felt that the computer activities should be more structured. She wanted more control over the activities her students were engaged in. A specific activity was chosen for each classroom period and this was changed every few weeks. During the language arts session, students worked on language arts activities such as Speed Read, Spell Game & Storymaker (a story generation program). During math, activities such as math drill & test, place value simulations (Applejack and Applecalc) and an estimation game (Harpoon) were used. In BR's class, activities included Typing Tutor (a typing tutorial program) and the Storymaker program. Again the activity was constrained by the

teacher, although it was not necessarily related to specific activities in the rest of the classroom.

The nature of these initial computer activities can be characterized as "computer centered." These activities were not integrated with specific curricular objectives, but rather were more concerned with competence in using the computer. All of the teachers who had unsequenced computer activities stressed that they wanted the students to feel "comfortable with the computer." This was of particular concern for the K-1 teacher. She expressed her concerns as follows: "... Would the mechanics be too difficult? Would playing games be too difficult? Would working the keyboard be too difficult? Or would playing with computer motivate them enough to learn their letters, numbers and words in order to acquire computer literacy?" (Quinsaat, 1982).

BM and BR worked to integrate the computer into their curricula but had not yet organized computer activities into a long range sequence. BM's activities were remedial or designed to enrich specific areas in the general curriculum such as addition facts. The computer was used as a motivational aid for the remediation of spelling, reading skills, and addition and multiplication facts. BR's activities, while not unsequenced, were not initially concerned with long range curricular objectives either. The computer activities functioned as stand alone lesson components which could be interchanged without interfering with the underlying pedagogy for both BM and BR.

These results are not surprising when we consider that none of the teachers in this study had prior computer experience. This initial computer-centered use of computers might be viewed as just the first phase in computer development. For these teachers, bringing the computer into their classroom required reorganization of the classroom environment. Smooth integration into the daily routine and the development of computer competence in the students became a need of primary importance and varied in degree of difficulty. Both the teacher their students had begun to master the machine. At this point, the use of the computer began to change.

Integrating Computer Use

The initial phase of computer use put much emphasis on the computer itself and on its organization into classroom activities. Over a period of several months, students and teachers gained more experience with the computer and its software. Computer use became more routine for both teachers and students.

Student cooperation proved to be one way of enhancing the efficiency of computer use in the classroom. Working in pairs, they could collectively resolve problems that occurred in the course of computer activities. As one student operated the keyboard, the other might search for keys or offer other advice. In one instance a pair of children were working together on an number estimation game (Harpoon). The objective was to estimate the location of a shark and then enter a number indicating the location to check their accuracy. One student entered a guess and nothing happened. Fortunately, his partner caught the error, "No, [student 1], you have to press RETURN," and the game proceeded.

Out of interactions such as these, certain students emerged as computer

"experts." Student experts were found in both the 3-4 and 4th grade classrooms. Larry was one such expert and was often called upon by BM to help other students. One day, while BM was involved in a reading lesson, students encountered some problems on the computer. The teacher sent Larry to help and he quickly got the program running again without teacher intervention.

Student-student interaction helped to smooth over problems encountered during computer operation, reducing the need for teacher intervention. The teachers, however, were often called upon to clarify more complex problems such as when the students accidentally exited the program and could not easily find their way back. Helpful hints began to appear on cards taped to the computer or on nearby blackboards. Directions were clarified. In BM's classroom, the phrase "Press RETURN when the computer winks at you" was reformulated for one pair of students as "When the computer blinks at you, press RETURN".

Increasing teacher experience and knowledge further improved the use of the computer. Just as students learned from students and the teacher, teachers learned from other teachers and outside computer experts. For example, BM learned a trick for "re-booting the system" through a course she was taking near the end of the school year. This entailed entering the cryptic statement "PR#6." She told CB, who had only used the computer a couple of weeks, and CB's students quickly made use of this new trick. The use of outside resources at critical points was an important factor in improving computer use.

BM had taken advantage of outside expertise to improve computer use. Continuing technical support greatly aided computer development. Technical support through the university was available for all the teachers studied. If problems arose with the hardware, university personnel aided the teacher in "debugging" computer problems and providing them with specific information when requested. While sometimes trivial, these problems could bring computer use to a grinding halt. In one case, the problem of a malfunctioning monitor was resolved when the outside expert suggested turning the contrast knob. Much to the teacher's chagrin, this solved the problem.

Outside expertise also aided the process of software selection. As students became familiar with activities, they asked the teacher for new "things" to do. The students could be heard to say, "...this is boring...." MQ, BM and BR were sensitive to this need and attempted to introduce new activities from time to time. Access to outside expertise was important because it aided the teachers in finding new activities. Given the myriad of educational software available, the university personnel helped separate "the wheat from the chaff." BR noted that, "the people involved [from the university] ...were aware of most of the educational programs available and were able to steer me towards the high quality ones. This was extremely helpful." BM also agreed that "knowing what software was available" proved very important in helping her to shape computer use.

Sometimes, though, there was no immediate solution to requests for new software. In the case of MQ's classroom, there was a lack of appropriate software for the K-1 students. Since most available software was textually based, new activities required a great deal of verbal support from MQ because her students couldn't read. This restricted the range of possibilities and in some sense restricted the development of computer activities.

In both the BM's and BR's class, new activities were introduced every couple of weeks. BM introduced new activities, such as Harpoon and Match Game (a memory categorization game) and BR began using Harpoon. The teachers desired to do more with the computer. BM wanted to "integrate" the activities more. After taking a summer writing course, she wanted to introduce more writing instruction in the coming year. Learning that writing software was available, she developed new plans for the computer. "I saw that the computer could be used in the writing process. It was an opportunity to merge the two processes [computer use and writing]." BR noted this change as well and commented as follows, "While we did not have a set sequence of activities we began feeling the need for one. Subsequently we began thinking about how writing activities on the computer should be sequenced. Being a teacher who stressed writing, I finally felt I could begin contributing to the project. As the year progressed, I felt more competent and I was able to give them [the researchers] more input" (Rowe, 1982).

What characterizes this period of activity was a progression from computer centered goals of competence to a concern for a sequence of activities. The computer was no longer viewed as the sole object of the lesson nor was it viewed as a device for provide remediation. Rather, a desire to merge the curriculum with the computer emerged. A desire for the computer to become a mediator of a curricular goal emerged. For BM and BR in particular, the goal was to teach writing through the computer. The teacher's curricular goals became increasingly mediated by the computer.

Computer Mediated Computer Use

Both BM's and BR's began to implement computer mediated writing activities. Both teachers began these activities began near the end of their second semester of computer use. They began to use the computer as a tool to meet their writing curriculum objectives.

BM had a new classroom in the fall of 1982. This was her second semester of computer use and she was in the process of developing her computer mediated writing curriculum. Her activities were scheduled similar to before, with the computer being used in language arts and reading. She stated that her first goal was for the students to gain keyboard familiarity. To meet this end she had the students work on tutorial programs such as Master Type and Typing Tutor. In addition, there was continuing of enrichment activities such as Harpoon and Spell. These enrichment activities were also serving to aid in keyboard familiarization.

Near the end of the fall semester she introduced a text editor and taught the students how to modify pieces of text which she had entered. It was necessary for them to know editor commands to progress to the next step in the writing curriculum. With her students now prepared, she introduced them to a new sequence of writing activities which she had developed. She used an interactive expository writing tool (Interactive Text Interpreter, developed at UCSD) which provided a structured environment for writing.

Initially, the students were asked to substitute words in teacher prepared stories. Gradually students were required to enter more of their own prose until they were writing their own stories and articles. This project operated on a two week cycle. An activity was introduced on Monday and students worked on the computer, entering their stories. Friday was set

aside for editorial work in small groups. In the afternoon the entire class helped revise stories. The following week authors entered changes and then, on Friday, all the students shared their stories.

The students went through a similar writing sequence in BR's classroom. They began using interactive tools to write a school newspaper. They worked in pairs to write an article on the weather, for example. Once written, this story was scrutinized by another pair of students who served as editors and would correct grammar, spelling and style. Different pairs of students were periodically assigned to serve as editors.

Both BM and BR made extensive use of their computer as a tool. The interactive writing tools were able to support activities for an entire semester. The computer served as a mediator for the activity of writing. This stands in contrast to previous activities in which computer lessons were independent of each other. Both the teacher and their students had become active participants in learning. The content and sequence of the lesson was organized by the teacher while the students were offered support for their writing. In a sense, the computer as a separate object of study had disappeared. It became a tool for mediating the learning process between student and teacher.

The use of computers had changed over time for these teachers. As their skills developed, they became resources for their own schools, providing inservice training and software to fellow teachers. The development of computer use in these classrooms leads to some important conclusions on how to implement computer technology in other classroom.

Conclusion

Given that computers will be entering elementary schools at an ever expanding rate, the process described here may have important policy implications. The initial use of computers was typified by a focus on the computer itself. Both the teachers and the students were previously unfamiliar with the computer. Initially the teacher had many managerial and technical concerns and doubts about whether the computer could be successfully used. Gradually, the teachers began to feel more comfortable with the machine and began to introduce new activities. As their experience with these activities improved, they were better able to define what they wanted in terms of computer activities.

Instructional goals changed. The need to chain the activities together to meet a specific curricular objective began to emerge. Finally the computer emerged as a mediator of the activities. The curriculum became the driving force behind computer use. At this point the software became more "tool" oriented. This shift from remedial or drill and test software to other computer uses has also been reported in a recent nationwide survey of computer use (CSOS, 1983).

The shift towards computer mediated lessons was the result of several key factors. First, the teachers were motivated and willing to experiment with computers. They were able to manage the computer effectively in the classroom environment. They were willing to seek help from outside sources and were fortunate to find well qualified support personnel. The support personnel helped them with technical problems as well as steering them towards new software and they were available on an ongoing basis.

This support proved to be vitally important for it reduced the effort required to seek out software and provided them with technical assistance. When this support failed, as was the case in the K-1 classroom, the development of computer mediated activities was halted. The lack of good software could inhibit good computer use.

Flexibility was important. New activities were introduced through a combination of student requests and teacher perception of their abilities. When a given activity was mastered, new software was introduced. This flexibility reduced frustration on the part of the students and the teacher. This encouraged all the students and the teachers to develop competence on the computer. Frustration could seriously hinder the effective use of computers.

Only when teachers feel comfortable with computers will they begin to experiment and view computer use as something other than an end in itself. A technical support network must become established inside and outside the classroom. The forced introduction of a sophisticated computer curriculum such as writing could quickly result in frustration unless the teacher and students have sufficient experience and access to technical support.

Recommendations

In the initial phases of computer use, teachers should be provided with inservice training and carefully selected software. A "network" of computer-using teachers could also help the novice by providing technical advice, ideas for managing the computer in the classroom, and access to software. As teachers become more familiar with the computer, they are likely to become more interested in integrating software activities into existing curriculum objectives, much as the teachers did in this study.

Second, some form of institutionalized support is needed to provide teachers with access to a range of software and convenient technical assistance. A support network should accommodate the diverse needs of teachers and administrators. Without technical support and access to good software, the ability of teachers to effectively integrate the computer into their instruction may be considerably reduced.

Finally, the teachers should be encouraged to be flexible in the way they implement computer activities. Teachers have varying degrees of computer knowledge, experience, and different instructional goals and objectives. It is likely that innovative teachers will develop effective instructional uses for computers, given adequate support and software. Constraining the range of curriculum within this dynamic process may frustrate the development of innovative methods for using computers. This technology is so new that prematurely settling on a restricted set of uses for computers may, in the long run, be counter productive.

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